DIFFERENTIAL ATTENTIONAL RESPONDING BY PLANNED AND EMERGENCY CAESAREAN-SECTION VERSUS VAGINALLY DELIVERED INFANTS AND ADULTS

MARYAM RAHIMI

A THESIS SUBMITTED TO
THE FACULTY OF GRADUATE STUDIES
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF ARTS

GRADUATE PROGRAM IN PSYCHOLOGY
YORK UNIVERSITY
TORONTO, ONTARIO

AUGUST 2019

Abstract

Search asymmetry occurs when feature-present targets are detected more easily than feature-absent targets, resulting in an efficient search (i.e. flat RT - set size function) for feature-present targets, but an inefficient search (i.e. increasing RT – set size function) for feature-absent targets. Both 3-month-old infants and adults have been found to exhibit a search asymmetry when assessed with saccade latencies (Adler & Gallego, 2014). Additionally, caesarean-section delivered infants exhibit slower attention and saccadic latencies than those born vaginally (Adler & Wong-Kee-You, 2015). This study is designed to determine the relative effects of different birth experiences on attention and search asymmetry performance and whether differences persist in adulthood. Two different visual circular arrays were presented: feature-present target among feature-absent distractors (R among Ps) or feature-absent target among feature-present distractors (P among Rs) with array set sizes of 1, 3, 5, 8. Results indicated that infants' and adults' saccadic latencies were unaffected by set size in feature-present arrays, suggesting an efficient search. Both caesarean-section born infants and adults had slower saccadic latencies when compared to the vaginal groups. Interestingly, infants born via planned caesarean-section were slower when compared to an emergency caesarean-section. There were no differences in saccadic latencies, however, between emergency and planned caesarean-section adults, suggesting that any difference due to planned vs emergency caesarean-sections does not persist into adulthood. For feature absent targets, both infants and adults exhibited increasing saccadic latencies with set size, suggesting an inefficient search. These findings suggest that any caesarean-section birth influences bottom-up attention and requires greater reliance on top-down processing even into adulthood. Thus, the development of attentional mechanisms can be influenced by early birth experiences that also impact adulthood.

Acknowledgements

I first and foremost need to thank my supervisor and mentor, Dr. Scott Adler, because without him this thesis would not have been possible. I appreciate all the support and help over the last two years when learning research skills and expanding my knowledge about infant eye literature. I also wanted to thank my colleagues, and now friends, Audrey Wong-Kee-You and Kyle Comishen for welcoming me into the lab and always being there when I needed help. Thank you for your diligence, brilliance, and patience while I learned the ropes. To all my volunteers who helped collect data and reach out to parents, thank you for making my time in the lab so much better. Finally, to all the parents who took time out of their busy schedules to bring in their children to participate, I cannot thank you enough for allowing our research to happen, all the tips and tricks for infants, and amazing conversations we shared.

Also, a special shout-out to my family and friends for putting up with my infant literature talks, although not always interested, and complaining when I may have gotten stressed. You all kept me on tract and in a positive mindset! To my parents, for enabling me to pursue my master's degree and always being super supportive, I appreciate you more than words can express. A special thanks to my fiancé, Shahin, for being encouraging during these past two years and always being by my side. I love and appreciate you all!

Table of Contents

List of Figures

INTRODUCTION

Birth Experience

Many studies have recognized the importance of experience in the development of cognition in behavior and the brain structures involved (Greenough & Black, 2013). Exposure to more than one language, for example, within early development has demonstrated long-term impacts on cognitive functioning (Mohades, Struys, Van Schuerbeek, Mondt, Van De Craen, & Luypaert, 2012). Cognitive development has also shown to be influenced by experience with different methods of feeding when comparing breast-feeding to formula (Quigley, Hockley, Carson, Kelly, Renfrew, & Sacker, 2012). Experience can alter the configuration and preservation of synapses throughout development, influencing mechanisms involved in neural plasticity (Maurer, Ellemberg, & Lewis, 2006). Various experiences, beginning at birth, impact the development of synaptic structure, yet the role of birth itself and its influence on the development of cognition has not been properly investigated. There are multiple forms of birth experience, where each individual has a unique unfolding sequence of events. Generally, births are categorized into two broad groupings; vaginally delivered infants and those born via caesarean-section. Studies have assessed the birth experience of the infant and its relation to an increased risk of developing diabetes (Cardwell, Stene, Joner, Cinek, Svensson, Goldacre, & Patterson, 2008), increased likelihood of becoming obese (Fleming et al., 2013), and developing allergies (Renz-Polster, David, Buist, Vollmer, O'Connor, Frazier, & Wall, 2005). None of these studies, however, have investigated the potential risks for cognitive developmental that might emerge from caesarean-section births relative to vaginal births.

One recent study, however, has looked at the cognitive mechanisms of 3-month-old infants, specifically visual spatial attention and the associated eye movements, relative to their birth experience (Adler & Wong-Kee-You, 2015). The first experiment in the study used a Posner (1980) spatial cueing task in which performance is thought to typically be driven by bottom-up attentional mechanisms (Theeuwes & Belopolsky, 2010). Results indicated differences in reactive saccadic latencies depending on infants' birth experience. Saccadic latencies of caesarean-section born infants were significantly slower in all three target conditions. In a subsequent experiment to further assess the influence of infants' birth experience on their visual attention, Adler and Wong-Kee-You (2015) used the Visual Expectation Paradigm (Adler & Haith, 2003; Haith, Hazan, & Goodman, 1988) where infants learn to expect a predictable sequence of pictures and then exhibit eye movements in anticipation of forthcoming pictures. Top-down attentional mechanisms are activated in this task because anticipatory eye movements must be cognitively guided by the expectation of which side the stimulus would appear or which stimulus would appear since they occur prior to the presentation of the anticipated stimulus (Adler & Haith, 2003; Adler, Haith, Arehart, & Lanthier, 2008). In this second experiment, the proportion of anticipations made by both vaginally and caesarean-section born 3-month-old infants did not differ, but reactive latencies after picture onset did differ in the same direction as in the first experiment. The results of these experiments suggest that birth experience does not interact with cognitively-driven, top-down, spatial attention processing. Instead, birth experience and caesarean-section in particular seems to influence stimulus-driven, bottom-up processing. In the current study, we aim to further investigate the influence of the birth experience on bottom-up versus top-down attentional mechanisms by having infants perform a visual search task. Additionally, infants born through caesarean-section will be sub-divided into two subgroups,

comparing emergency versus planned-caesarean-section births. Planned-caesarean-section births are those with a predetermined delivery date set by the doctor, whereas emergency caesarean-section births are classified by births where the mother does go through some initial stages of labour prior to the caesarean-section birth. This will allow for a more in-depth comparison of caesarean-section-born infants, which may reveal nuances relative to potential theories regarding the mechanism by which caesarean-section birth influences visual attention.

Selective Visual Attention

It is important to better understand the nature of selective attention, as it has been suggested to be impacted by the birth experience. People rely on attentional selection to filter through relevant and irrelevant information in the environment to ensure efficient behavioural and cognitive processing (Adler & Gallego, 2014; Driver, 2001; Posner & Peterson, 1990; Theeuwes, 2010). Visual attention enables individuals to selectively attend to particular information while ignoring unrelated information that may also be simultaneously available (Adler, Bala, & Krauzlis, 2002; Theeuwes, 1994). Infants are more limited in their processing resources relative to adults (Dehaene-Lambertz & Spelke, 2015), making it crucial to selectively filter the increasing amount of new information regularly encountered (Adler, 2005; Adler & Gallego, 2014; Rose, Feldman & Jankowski, 2004). Selective attention influences processing by inhibiting task irrelevant information, thereby directing some processing resources to task relevant information (Theeuwes, 2010; Yantis & Egeth, 1999). Importance is placed on the development of the mechanisms responsible for guiding the selective distribution of attention, considering the infant's limited available resources that are active in construction and learning of constantly presented stimuli (Colombo, Mitchell, Coldren, & Atawater, 1990).

With adults, assessment of visual search behavior is one of the main avenues, as well as cueing effects (Posner, 1980), for gaining a better understanding of the attentional system. Typically, in basic visual search tasks, the nature of the selective division of attentional resources determine the level of efficiency in searching (Wolfe, 1998). In most developmental studies of attention, only one stimulus (or, at most, two) is presented and consequently no search and no selective division of attention is required (Adler, 2005), assessing infants' attention in visual search scenarios therefore provides a means to more accurately gauge the development of the selection component of attention. The development of visual search, therefore, has gained increasing interest with the conduction of recent studies in hopes of better understanding the changes and differences of development of selective attention (Adler, 2005; Adler & Gallego, 2014; Adler & Oprecio, 2006; Colombo, Ryther, Frick, & Gifford 1995).

Visual Search and Processing

Visual search was initially characterized by an early model of visual processing (Julesz, 1984; Neisser, 1966). This framework, called Feature Integration, theorized that attention plays a prominent role in visual processing as part of a two-stage model, consisting of preattentive and attentive phases (Julesz, 1984; Neisser, 1966; Treisman & Gelade, 1980). Preattentive processing was hypothesized to detect the basic features of visual information automatically and in parallel across the visual field without having to focus any attention on specific items (Julesz, 1984; Treisman & Gelade, 1980; Treisman 1986). As a consequence, allocation of attentional resources are automatically and selectively directed to a stimulus when it contains a unique perceptual feature different than the background or other simultaneously available stimuli (Julesz, 1984; Treisman & Gelade, 1980; Treisman & Gormican, 1988). This phenomenon is commonly referred to as the pop-out effect (Wolfe et al., 2003), which is characterized by the production of

an efficient search where speed and accuracy to locate the unique target are independent of the number of distractors or objects present in the display (Treisman & Gelade, 1980). The pop-out effect, where the target contains a unique distinguishing feature, generates a signal allowing for allocation of the attentional processing resources without having to move the search to the attentive phase. Subsequently, when a stimulus is not defined by a unique perceptual feature, an inefficient search ensues where the speed and accuracy of target location increase as the number of surrounding distractors also increase (Treisman & Gelade, 1980). Attention is then allocated to the attentive stage, due to the lack of saliency presented in the preattentive phase inhibiting automatic detection, where processing resources attentively search around the display item-by-item to locate the target (Krose & Julesz, 1989). As a result, visual selection occurs when processing resources shift from the initial preattentive to the attentive stage (Theeuwes, 2010; Treisman & Gelade, 1980). Studies have now shown that this early model describing visual processing as a two-stage system consisting of the two distinct, preattentive and attentive, phases does not accurately account for all visual search effects (Cave, 1999; Di Lollo, Kawahara, Zuvic, & Visser, 2001; Theeuwes, Kramer, & Atchley, 1999). Instead, more recent models postulate that one mechanism accounts for a range of different search types.

Human visual search and attention has more recently been described by a Guided Search (GS) model in which observers look for a target amongst a number of distractors set by the experimenter (Wolfe, 2007). In the Guided Search model, two different types of preattentive guidance are implemented, bottom-up and top-down processing (Wolfe, 2001). How these levels of guidance interact with the presence or degree of distinctiveness of perceptual features, enables whether or not items stand out, influencing the saliency signals produced by the engagement of these different levels of processing (Wolfe, 2001). Bottom-up processing directs attention to a

stimulus that is defined by a unique feature not shared among the distractors. Bottom-up processing involves the refinement, further processing and filtering, of in-coming sensory information (Wolfe, 1994). Targets with a unique differentiating feature are referred to as feature-present targets, compared to feature-absent targets, that do not consist of a unique feature existing among the distractors. Feature-present targets, when compared to their neighboring distractors, generate a solid bottom-up saliency signal. The saccade latency or reaction time (RT) are independent of the number of distractors presented in the array, helping guide an efficient search (Wolfe, 1994). Attention is automatically directed towards highly salient objects that standout in their environment, immediately grabbing attention (Theeuwes, 2010). Whereas with feature-absent targets, greater reliance is placed on top-down activation due to the weaker saliency signals produced, where the target does not readily stand out, resulting in an inefficient search (Wolfe, 2001). The saliency signals are dependent, and therefore weaken, as the number of distractors increases because the features become less distinctive (Wolfe, 1994). As opposed to Treisman's Feature Integration model (1980), the GS model allows for a continuum of efficiency and involves both top-down and bottom-up processing in every search because the target may not always produce enough of a saliency signal to engage only bottom-up attention and may also be biased by top-down processing (Wolfe, 1994, 2001). As the saliency difference increases, between the target and distractors, then the bottom-up processing can more easily detect the target. The GS model disregards Treisman's step-wise mechanism, instead focuses on the interaction between bottom-up and top-down processing allowing for a continuum of efficiency. One particular visual search phenomenon that illustrates the integration of top-down and bottom-up processing is the exhibition of a search asymmetry.

Search Asymmetry

Search asymmetry occurs when search for a feature-present target versus search for a feature-absent target produce different performance outcomes. Feature-present targets contain a unique feature that is absent in all other distractors (e.g. Q among Os), resulting in an efficient search generating a uniform reaction time (RT) function independent of the set size (Treisman & Gelade, 1980). The existence of a unique feature causes automatic and selective allocation of attention guiding it to the stimulus, thus producing a pop-out effect (Julesz, 1984; Treisman & Gormican, 1988). Whereas feature-absent targets in which the target is missing the unique feature present among the distractors (e.g. an O among Qs) produces an inefficient search where reaction time increases with respect to increasing set sizes (Colombo et al., 1995; Treisman & Gelade, 1980). The Guided Search model (Wolfe, 1994) explains that the feature-present targets have a unique perceptual feature compared to the neighboring distractors that produce a strong bottom-up saliency signal, in comparison to a feature-absent target that produces weak bottom-up saliency signals.

There are many studies with adult participants demonstrating search asymmetries (Nagy & Cone, 1996; Royden, Wolfe & Klempen, 2011; Treisman & Souther, 1985), however, only a few studies have attempted demonstrating this phenomenon with infant participants (Adler & Gallego, 2014; Colombo et al., 1995). Infant studies often have many limitations regarding what can actually be classified as true visual search. Colombo et al. (1995), for example, used a preferential-looking model when attempting to study search asymmetry in infants aged 3- to 4-months old. Infants were presented with either a homogenous display (all Os or Qs), a feature-present display (Q among Os), or a feature-absent display (O among Qs). They established that infants as young as 3- to 4-months-old exhibited increased looking time when shown a feature-

present target Q among feature-absent distractors compared to homogenous feature-absent displays (all Os). However, when infants were shown feature-absent targets among feature-present distractors, looking time did not differ in comparison to homogeneous feature-present display (all Qs). These findings were similar to asymmetric visual search studies performed on adults, suggesting that similar attentional mechanisms develop in the early months of infancy.

Adler et al. (1998) later assessed search asymmetry in 3-month-old infants using a mobile conjugate reinforcement paradigm (Rovee & Rovee, 1969). Infants were trained for two consecutive days to kick a seven-block mobile displaying either all Rs or Ps. As these infants learned the task, their kicking rate increased. On the testing day, 24 hours after training, infants previously trained with homogenous R blocks were tested with a mobile containing six R blocks and one P block (feature-absent mobile). On the other hand, infants that received training with homogenous P blocks were testing with a mobile containing six P blocks and one R block (feature-present mobile). If the infants recognized the test mobile, then their kicking rate should remain at an increased level relative to training. Conversely, if they view the test mobile as novel and are able to detect and discriminate the unique. novel block relative to training, then their kicking should be similar to when they were first exposed to the homogenous mobile on the training day, prior to learning. Results indicated that infants in feature-absent mobile kicked at significantly high rates and were likely unable to discriminate between the different mobiles. In contrast, infants in the feature-present target condition exhibited discrimination where the kick rate returned to the pre-learning rate. This difference suggests that in the feature-present mobile, the target predominately directed attention, whereas in the feature-absent mobile the familiar distractors governed the attention. The overall findings insinuate that the feature-present R block

create a pop-out effect and provide evidence for the presence of search asymmetry in infants as young as 3-months old.

More recently, a study by Adler and Gallego (2014) looked at differences in 3-month-old infants' and adults' eye movement latencies on a visual search asymmetry task. Adler and Gallego (2014, also see Adler, 2005; Adler & Orprecio, 2006) argue that in studies such as novelty-preference, preferential-looking, and mobile-conjugate, there may be issues with timing of presented stimuli and set size. The use of time scales that include seconds and minutes when assessing infant behavior can result in other cognitive processing having sufficient time to also influence behavior. As a result, search mechanisms may not be the only determining factor in influencing the infant's behavior. Conducting a visual search task measuring saccade latencies in both infants and adults allows for more accurately assessing selective attention and visual search mechanisms, while also using a timescale consisting of milliseconds. Adler and Gallego (2014) also argue set size, a critical parameter for determining whether an efficient or inefficient search has occurred and the relative roles of bottom-up and top-down mechanisms, has not been assessed in any of the previous infant studies mentioned. Finally, accurate determination of visual search and attentional development could not be drawn because direct comparisons between infants and adults could never be made with such obvious differences in methodology and timing between these populations.

If comparable methodology could be designed, then a more accurate picture of the development of attention and early visual search could be painted. To this end, Adler and Gallego's (2014) search asymmetry study used the same eye movement methodology and stimulus parameters with infants and adults. Infants and adults were presented with randomized displays of either homogenous (all Rs or Ps), feature-present (R among Ps), or feature-absent (P

among Rs) stimulus arrays occurring in one of four possible set size configurations (1, 3, 5, or 8). Targets in non-homogeneous displays could appear in one of four locations (3, 6, 9, and 12 o'clock). Similar to the adults, infants were able to selectively allocate attention and localize the target in feature-present arrays (R among Ps) efficiently. With the feature-absent arrays (P among Rs), however, localization of the target was more inefficient. Target information was not provided to the infants prior to presentation of the search arrays, thus eliminating any top-down biasing, suggesting that infants' attentional allocation is being guided in a bottom-up manner (Wolfe, 1994). Differences in target localization provide support that attentional mechanisms in selective processing, specifically bottom-up target saliency, are not only present in adults, but also 3-month-old infants. Furthermore, these visual search findings suggest that top-down and bottom-up attentional mechanisms likely have different developmental timelines (also see Amso & Scerif, 2015; Braddick & Atkinson, 2011). In the current study, we use Adler and Gallego's (2014) study as a basis for understanding the relative impact of birth experience on bottom-up versus top-down attentional mechanisms and introduce a new division within caesarean-section group in an attempt to understand the process by which birth experience has its impact.

Visual Attention and Birth

Attention is an information-processing mechanism that serves as a filter for information from the world as well as information from mental activity, where attentional resources are allocated to important information that fill the limited accessible capacity, instead of irrelevant information (Conway & Engle, 1994; May et al., 1999). One paradigm for measuring the development of attention can be done by mapping and measuring eye movements. Tracking eye movements allows researchers to more precisely measure where attention is being directed (Duc, Bays, & Husain, 2008), while also looking at saccade directions and speed to better determine the

development of attentional networks (Hoffman & Subramaniam, 1995; Deubel & Schneider, 1996; Posner, 2016). Birth experience may be the cause of differences in the development of attention which can be studied through saccadic eye movements. There are two potential theories that explain how the differences in birth experience might impact attentional allocation. One theory was proposed as an outcome of a study by Toda et al. (2013) which revealed that the birth experience of rat pups affects and results in brain development differences. Rats were induced to give birth prematurely, consequently resulting in accelerated development of the barrel formation postnatally in the rat pups. The accelerated differentiation in the rat pups' brains was theorized to be due to a decline in serotonin level, as initiated by the birth process, that triggered the accelerated development of that brain region; in humans, the analogous somatosensory cortical region has been shown to be involved in spatial attention (Balslev, Odoj, & Karnath, 2013; Jones et al., 2010). Interestingly, Toda et al. (2013) also found that barrel formation was slowed, not significantly though, for pups born via caesarean-section when compared to those born vaginally. Thus, these findings suggest that differences in the birth process itself and the lowering of serotonin levels that is initiated by the onset of labor, whether being born prematurely or through some caesarean-sections but not others, might likely affect the development of the somatosensory cortex and consequently visual attention mechanisms.

A second theory proposes that differences between infants born by caesarean-section and those born vaginally may be a consequence of the involvement of passage through the vaginal canal and its influence on seeding the neonate's gut microbiome (Cryan & Dinan, 2012; Galland, 2014). Vaginally born infants are initially exposed to bacteria through the vaginal canal of the mother (Bezirtzoglou, 1997), whereas caesarean-section infants are first exposed to bacteria originating from the hospital environment, healthcare professionals, and the mother's skin

(Bezirtzoglou, 1997; Gronlund et al., 1999, Polidano, 2017). Some studies have suggested that differences in children's cognitive development, specifically negative associations, may be directly related to caesarean-section births due to differences in the gut microbacteria of these infants (Polidano, 2017). Lending credence to this notion is the recent finding that gut mictrobacteria can send chemical signals to the central nervous system and affect memory (Cryan & Dinan, 2012; Galland, 2014). During the sensitive time of early brain development, consequently, differences in the birth experience might differentially expose or initiate the seeding the microbiome, which in turn might play a role in long-term cognitive effects (Polidano, 2017).

Both theories provide potential explanations related to birth experience and its connection to differences in brain development and the allocation of bottom-up visual attention. Both theories, however, rely on different phases of the birth process. In the serotonin theory, all that seems to be required is experience labor to initiate the decreasing serotonin level cascade. In the microbiome seeding theory, the infant is required to traverse the birth canal. These theories would consequently make different predictions for infants born via an emergency caesarean-section in which labor is at least partially experienced versus planned caesarean-section in which no labor is experienced.

Current Study

The current study aims to examine the difference in stimulus-driven, bottom-up, reflexive attention in infants who have been born vaginally, via emergency caesarean-section, and via planned caesarean-section. Adler and Wong-Kee-You (2015) have previously shown evidence that differences in bottom-up attentional processing occurs in infants as a consequence of their

birth experience. Previous studies have also shown that 3-month-old infants exhibit search asymmetry, which is theoretically defined by differences in the engagement of bottom-up versus top-down attentional processing, similar to that exhibited by adults (Adler & Gallego, 2014). The purpose of this current study is two-fold; first, to confirm previous results and to determine whether there is differentiation in the bottom-up saliency map of infants due to different experiences during birth. Secondly, we seek to further investigate the theoretical relation between birth experience and cognitive developmental outcomes. By comparing emergency caesarean-section infants to infants born by planned caesarean-section will potentially enable a differentiation between the serotonin and the microbiome theories. Infants born via emergency caesarean-section are those that have gone through early onset stages of labour, but a complication resulted in caesarean-section birth, whereas planned caesarean-section infants had a predetermine date for delivery and no labour was initiated. If the microbiome theory is correct, then there should be no difference in infants' attentional performance as neither the emergency nor the planned caesarean-section infants traverse the birth canal. In contrast, if the serotonin theory is correct, then differences in attentional performance should emerge between the emergency and planned caesarean-section infants as the emergency caesarean-section infants do experience at least some labor that should initiate the decrease in serotonin, whereas the planned caesarean-section infants do not.

Additionally, as the impact of birth experience on bottom-up processing and visual attention is a relatively new find and whether the impact is transient, being exhibited only in early development, or more permanent is unknown, adults will be tested with the same search asymmetry task as the infants. Replicating the exact same methodology and measures with adults as with infants, allows for direct comparisons of attentional localization and eye movements to

be made across the developmental spectrum. This study will shed light on the importance of needing to understand the implications of early experience postnatally on cognitive structures. More importantly, if there are significant differences due to experience, it could lead to further experimentation in discovering the biological reasoning behind the differences.

EXPERIMENT 1: Search Asymmetry in Infants

Methods

Participants

Twenty-seven infants (21 males, 6 females), ranging in age from 84 to 118 days old, were recruited from multiple mailing lists purchased from a local marketing company (Z-Retail Inc.). These lists included the name of the parent, their mailing address, and the expected due date of the infant, all of which remain confidential. Laboratory information and an invitation to participate was included in a letter sent out to the mailing address provided. Parents interested in participating were encouraged to mail back a prepaid post card, fill out an online form, email, or call to gain more information and receive information regarding edibility. Upon arrival, parents are informed about the entire study, fill out a demographic questionnaire which includes information about the birthing experience, followed by a full walk-through and explanation of lab equipment, and then a filling out an informed consent form. Data is collected from infants born full term (±2 weeks of reported due date), without observable abnormalities, and born into middle socioeconomic status. Infants were grouped based on birth experience reported by parent(s) in questionnaire. Ten infants were born vaginally, eight infants were born through emergency caesarean-section, and nine born via planned caesarean-section without the mother going through any stages of labour. The infants in this sample were African (n = 5), East Asian

(*n* = 2), Caucasian (*n* = 9), Hispanic (*n* = 4), Middle Eastern (*n* = 2), South Asian (*n* = 1), and other (*n* = 4). Data from infants were excluded if there was failure in testing equipment (*n* = 3), fussiness (*n* = 18), or inattentiveness (*n* = 6). Fifty-seven infants were tested in total, of those, data from twenty-seven infants formed the final sample.

Stimuli and Apparatus

Computer-generated stimuli consisting of a centered white triangle, red Rs, and red Ps. All targets and distractors were presented on a gray background and arranged on a circular grid with a radius of 5^{o} around the central fixation. There were two different visual arrays presented: feature-present target among feature-absent distractors (R among Ps) and feature-absent target among feature-present distractors (P among Rs). There were 4 different set sizes shown: 1, 3, 5, 8 items (see Fig. 1b). Arrays with the set size of 1 were presented to represent a baseline for reactive saccadic latencies when no 'search' was required. The targets were randomly presented at either 3, 6, 9, or 12 o'clock positions to prevent target reoccurrence and anticipatory eye movements, and to enable more precise determination of correct eye movement localization (see Fig. 1a). All displays were randomly ordered for each participant.

In a specialized crib, infants are laid supine with a 48 cm IBM LCD monitor (1024 x 768-pixel resolution, an 8-bit/pixel grayscale, and a refresh rate of 75 Hz) mounted 48 cm above them. A 30 x 30 cm infrared-reflecting visible-transmitting mirror, located between the infant and the monitor, provided an unobstructed view of the stimuli presented. A remote pan-tilted infrared eye-tracking camera (Model 504, Applied Science Laboratories [www.a-s-l.com], Bedford, MA) was also positioned above the infant (see Fig. 2). Through the use of bright-pupil technology, the eye-tracker recorded the participants' eye movements via the reflection mirror at

a temporal resolution of 60Hz. A blacklit white pupil was produced by camera diodes emitting infrared light and reflecting that light off of the mirror and back off the infant's retina through the pupil. A point reflection was also produced by the infrared light on the corneal surface of the eye. Using a proprietary software (Applied Science Laboratories), the relation between corneal reflection and the centroid of the backlit pupil was used to calculate fixation location. To equate recorded eye-tracker values of eye location to known locations on the screen, calibration of the eye-tracker was completed by having infants fixate two concentric squares at fixated locations on the LCD monitor. The calibration values were used to filter all subsequently recorded eye-tracker data.

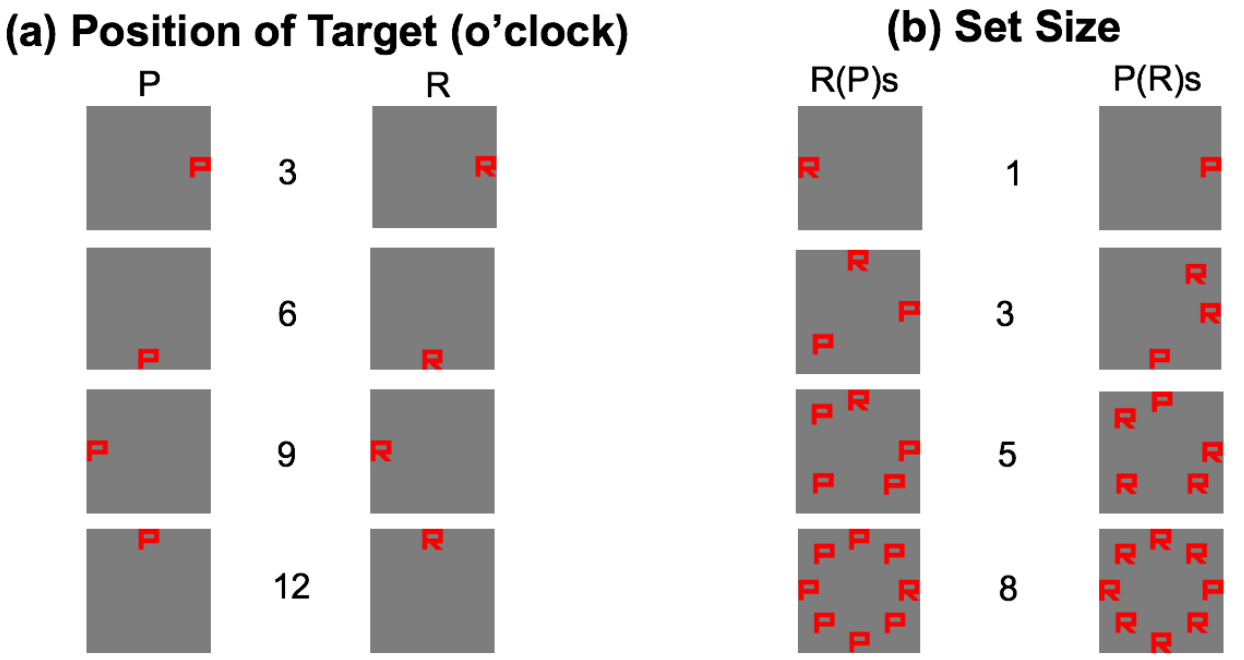

Fig 1. Examples of the stimuli shown in both infant and adult experiments. Shown are **(a)** all the possible target locations (3, 6, 9, and 12 o'clock) and **(b)** a randomly selected display of target item locations and different set sizes for both feature-present and feature-absent target conditions

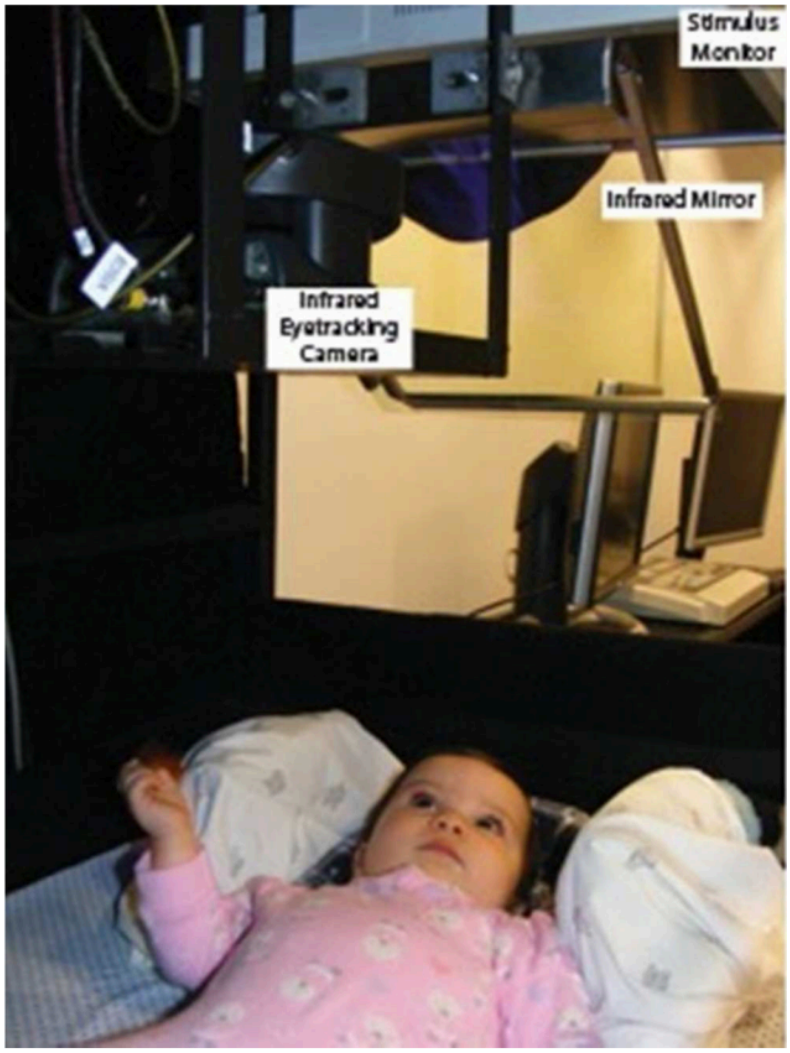

Fig. 2 Image of specialized crib used with infants, showing the monitor on which stimuli were presented, the Model 504 infrared eyetracking camera, and the infrared mirror

Task Procedure

Direct RT (Empirisoft Inc., New York; www.empirisoft.com/DirectRT.aspx) was run on a Dell computer for the experimental session and to time the stimuli. Each trail was initiated with a fixation triangle, at a visual angle of 1^{o}, at the center of the display for 1000 msec. This was followed by an interstimulus interval (ISI) for 250 msec, where the screen was blank. Following the ISI, one of the four stimulus arrays were presented for 1000 msec (see Fig. 3). The visual

arrays were randomized by feature presence and set size for each participant. A blank screen reappeared after the search array for an intertrial interval of 250 msec. A total of 32 trails were presented to each infant: 2 search arrays X 4 set sizes X 4 different target locations. Because infants may not pay attention to each trial presented, the trials were each shown 4 times totaling 128 trails.

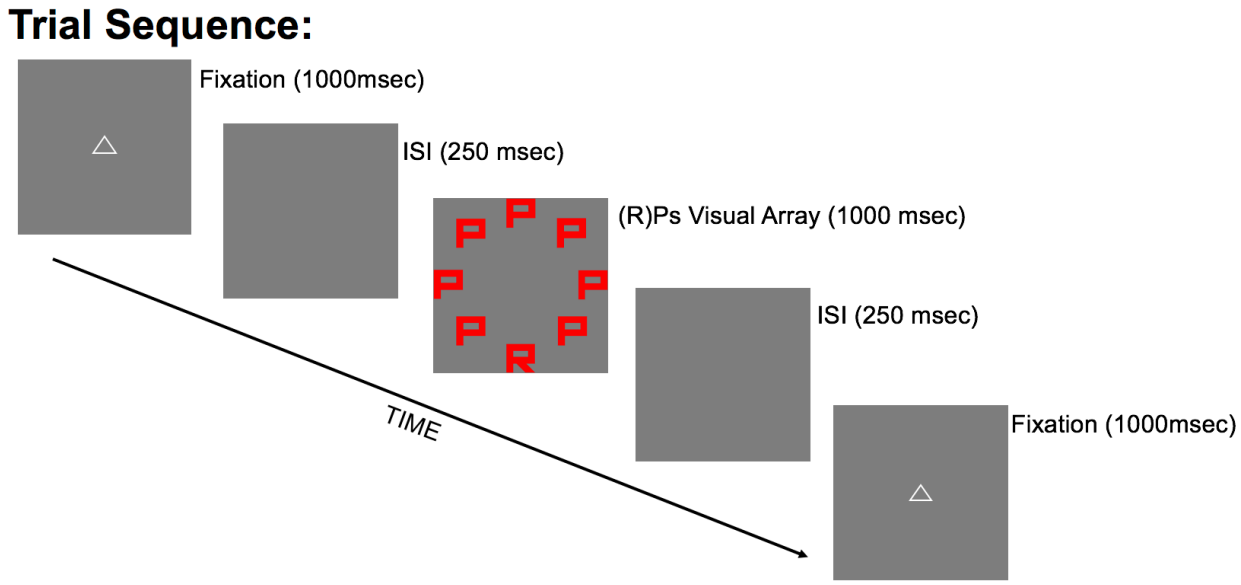

Fig 3. Sample trial sequence for presentation of visual arrays

Data Reduction and Analysis

The raw data recorded by the eye-tracker is imported into a MATLAB toolbox called ILAB (Gitelman, 2002). ILAB allows for analysis of each trial by displaying each eye movement separately by its x- and y-axis. The toolbox also displays the timing (msec) of each distinct eye movement location, allowing for a clear display of the scan path of the saccade. This helps determine whether the eye movement was initiated to localize the target. In order for an eye

movement to be included in the final data sample, it needed to meet a number of criteria. To determine the validity of eye movement, an initial velocity threshold was set for infant eye movements at 50 degrees/second setup as a derivative for distance from fixation to target location. An eye movement needed to be made 167 msec after the target array appeared, at its fastest. This latency cut-off was chosen because research has previously found that 3-month-old infants cannot make an eye movement in reaction to the onset to the stimuli faster than 167 msec (Canfield et al., 1997). Further, in order for an eye movement to the target to be considered valid, infants first needed to fixate the central fixation triangle, displayed prior to the search array. This criterion eliminated any differences in latency due to differences in the distance between the eye's initial location and the target's location. Infants needed to stay fixated for 133 msec after the original onset of the target display before making a saccade. Due to the inability to communicate with the infants and direct them to look at the fixation location, the re-centering of their gaze also equates their eye movements across search target conditions and allows the infant data to be comparable to the eye movement data from adults. The third criterion was that the infant needed to stay fixated at the target location for 100 msec, which is taken as an indication that the target was the intended endpoint of the eye movement and not random eye movement (Canfield, et al. 1997), in order for the saccade to be included. Fourth, infant's data were included if they had completed at least 60% of the trials to ensure adequate attention was presented throughout the whole task. Finally, eye movement needed to be follow to at least 50% of the path to the intended target from the fixation triangle. Previous studies have used this 50% criterion when looking at an infant's eye movement to indicate that the eye movement was intentional and not at random (Adler & Haith, 2003; Adler & Orprecio, 2006). Saccade latencies for each birth group were pooled for each set size.

To rule out the possibility that a select few of infants were responsible for skewing group means for each condition by set size, histograms were examined with outlier detection. All histograms revealed similar distributions for groups by set size and condition. Though not included here, please see Table 1 in Appendix for the standard error of each group by condition. As evident by the standard error, there was no violation of heterogeneity of variance. Together these measures provide evidence that group means were not due to a select few infants.

Results

Preliminary Analysis

Mean saccade latencies to an R and P target condition, with a set size of 1, were compared to ensure that there were no differences in reaction as a function of target type and birth experience simply due to stimulus onset. Previous developmental research has suggested that infant eye movements along the horizontal are more reliable and accurate than those along the vertical (Gronqvist et al., 2006), as a consequence, location of the target was analyzed to ensure the absence of any biases occurring due to differential maturation of the eye muscles responsible for controlling eye movements made to those directions. Additionally, location was analyzed to ensure that differences in the performance in the R and P target conditions were not due to the location of the target. A 2 x 3 x 4 ANOVA was therefore performed with target condition (R and P) and location (3, 6, 9, and 12 o'clock) as within factors, and birthing group (vaginal, caesarean emergency, and caesarean planned) as a between factor. The analysis revealed that the main effect of target condition was not significant, $F(1, 186) = 1.57$, *n.s.,* indicating that the mean reactive saccade latencies to a single R ($M = 402.55$ msec) and a single P ($M = 432.09$ msec) did not differ. The main effect of birthing group was also not significant,

$F(2, 186) = 0.72$, *n.s.,* indicating that the saccadic latencies, whether to the R or the P, among those born vaginally ($M = 410.63$ msec), via caesarean-section emergency ($M = 437.16$ msec), and caesarean section planned ($M = 402.41$ msec) did not reliably differ. The analysis also revealed a nonsignificant interaction between target condition and birthing group, $F(2, 186) = 0.63$, *n.s.* The different birth groups, therefore, exhibit similar mean saccade latencies when only 1 item is displayed indicating that the ability to make a saccade to the onset of a target without the presence of competing distractors is equivalent for each group. Furthermore, any differences in saccade latencies exhibited to feature-present and feature-absent target search arrays with set sizes greater than 1 could not be as a result of an inherent performance of differentiating between the two stimulus characters, regardless of the birthing group.

The main effect of target location, $F(3, 186) = 0.10$, *n.s.,* was also not significant, nor was the interaction of target condition and target location, $F(3, 186) = 0.09$, *n.s*. The interaction of birth group, target condition, and location was also not significant, $F(6,186) = 0.08$, *n.s.* A nonsignificant interaction between birth group and location, $F(6,186) = 0.07$, *n.s.*, suggests that any differences in saccade latencies between groups could not be due to differences in attentional allocation based on target location. Thus, the location of the stimulus target did not result in any differences in saccade latencies either by itself or in interaction with a particular target or birth experience. Accordingly, if differences in saccade latencies in R (feature-present) and P (feature-absent) search target conditions with arrays occur with set sizes greater than 1, therefore, those differences could not be due to any differences in the location of the targets within the array. Consequently, data in all future analyses were collapsed across location.

Saccade Latencies as a Function of Set Size

To investigate whether birth experience influenced attentional mechanisms, such as bottom-up and top-down processing, the mean saccade latencies produced by each birthing group were compared for each type of search array across the 3 different set sizes. A 3 x 3 x 2 ANOVA was conducted on the mean saccade latencies exhibited by infant participants as a function of birth experience (vaginal, caesarean emergency, and caesarean planned) as a between factor, and set size (3, 5, 8) and target condition (feature-present and feature-absent) as within factors. A significant main effect was found for birth experience, $F(2, 383) = 14.91$, $p < .001$, $\eta_p^2 = .07$, indicating that irrespective of the set size or target condition, infants' saccade latencies initiated to a target differed between the three birth experience groups. Tukey's HSD post hoc test compared the mean saccade latencies in the different birth experience groups and revealed that saccade latencies did not significantly differ for vaginal ($M = 560.56$ msec) and emergency caesarean-section infants ($M = 550.12$ msec), *n.s*. Saccade latencies of vaginally born and emergency caesarean-section infants, however, were both significantly faster than the saccade latencies of planned caesarean-section infants ($M = 592.50$), $p < .001$, *n.s*.

The omnibus ANOVA also revealed a significant main effect for set size, $F(2, 383) = 17.02$, $p < .001$, $\eta_p^2 = .08$, indicating that infants' saccade latencies significantly differed for each set size irrespective of the target condition or birth experience. Post hoc comparisons of mean saccade latencies using the Tukey HSD test indicated that saccade latencies for a set size of 3 ($M = 542.41$) were significantly faster than both set size of 5 ($M = 575.30$) and 8 ($M = 585.03$), $p < .001$. However, the set size of 5 did not significantly differ from the set size of 8, *n.s*. The main effect of target condition was also significant, $F(1, 383) = 141.75$, $p < .001$, $\eta_p^2 = .27$, demonstrating that saccade latencies did differ significantly for feature-present versus feature-

absent target arrays irrespective of either set size or birth experience. Infants made faster target-directed saccade latencies to feature-present target arrays (M = 530.14) than to feature-absent target arrays (M = 605.32), $p < .001$.

The ANOVA further revealed a significant main interaction between birth experience and target condition, $F(2, 383) = 3.73$, $p < .05$, $\eta_p^2 = .02$, indicating that as a result of different birth experiences infants' saccade latencies were significantly different for the two target conditions. The significant difference of the interaction needed to be further analyzed by controlling for each birth group. Three separate one-way ANOVA tests were conducted to determine whether each birth group had significant differences in mean saccade latencies when localizing a feature-present vs a feature-absent target. A significant main difference of target condition was shown for infants born vaginally, $F(1,136) = 49.6$, $p < .001$, $\eta_p^2 = .27$, via planned caesarean-section, $F(1,119) = 13.2$, $p < .001$, $\eta_p^2 = .10$, and emergency caesarean-section, $F(1,140) = 57.6$, $p < .001$, $\eta_p^2 = .29$. The findings indicate that, regardless of birth experience, each group had significantly slower mean saccade latencies when locating one type of target condition compared to the other (see Fig. 4 & 6). To further explore the interaction between birth experience and target condition, each target condition was separately controlled for with two separate one-way within factors ANOVAs to assess the effect of birth experience for each target condition. For the feature-present target condition, the ANOVA was significant, $F(2,204) = 17.28$, $p < .001$, $\eta_p^2 = .14$, suggesting a significant difference in mean saccade latencies of the different birth types (see Fig. 4). Tukey HSD post hoc tests comparing the mean saccade latencies in all three birth experience groups for feature-present target displays revealed slower saccade latencies for planned caesarean-section infants (M = 571.35) when compared to those delivered vaginally (M = 514.53), $p < .001$. Planned caesarean-section infants were also significantly slower when making

target-direct saccade latencies to feature-present targets than emergency caesarean-section infants ($M = 510.94$), $p < .001$. The target-directed saccade latencies of vaginal and emergency caesarean-section born infants, however, did not significantly differ.

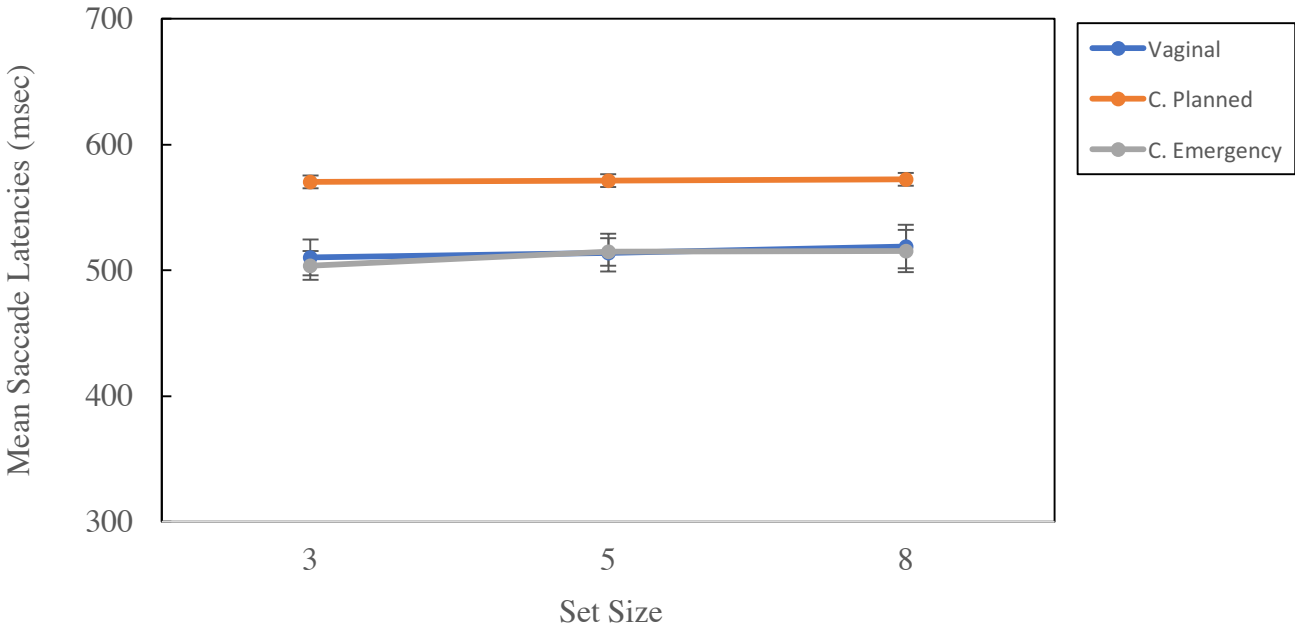

Fig. 4 Feature-present (R) target display. Mean target-directed saccade latencies for feature-present target condition plotted as a function of set size (3, 5, and 8 items) for each birth experience group. Independent of set size, mean saccade latencies remained the same. Planned caesarean-section infants performed significantly slower than both vaginally and emergency caesarean-section infants. Error bars indicated +/- SE.

For the feature-absent target condition, a second ANOVA was not significant, $F(2,191) = 0.71$, *n.s.,* indicating no meaningful differences in mean saccade latencies between the different birth types (see Fig. 4). There were no significant differences in mean saccade latencies between the vaginal and either group of caesarean-section infants. Given prior findings suggesting that one's birth experience interacts with stimulus-driven, bottom-up processing and not cognitively-

driven, top-down attentional mechanisms (Adler and Wong-Kee-You, 2015), these findings support the influence of birth experience on attentional selection and perhaps brain development, although the exact nature of how birth influences attentional and brain development is not yet fully determined. Each participants' individual mean saccade latencies were examined to determine if any specific set of trials were outliers and cause of skewing group means. Means of each participants' eye movements per set size in feature-present condition were similar with means grouped (see Fig. 5).

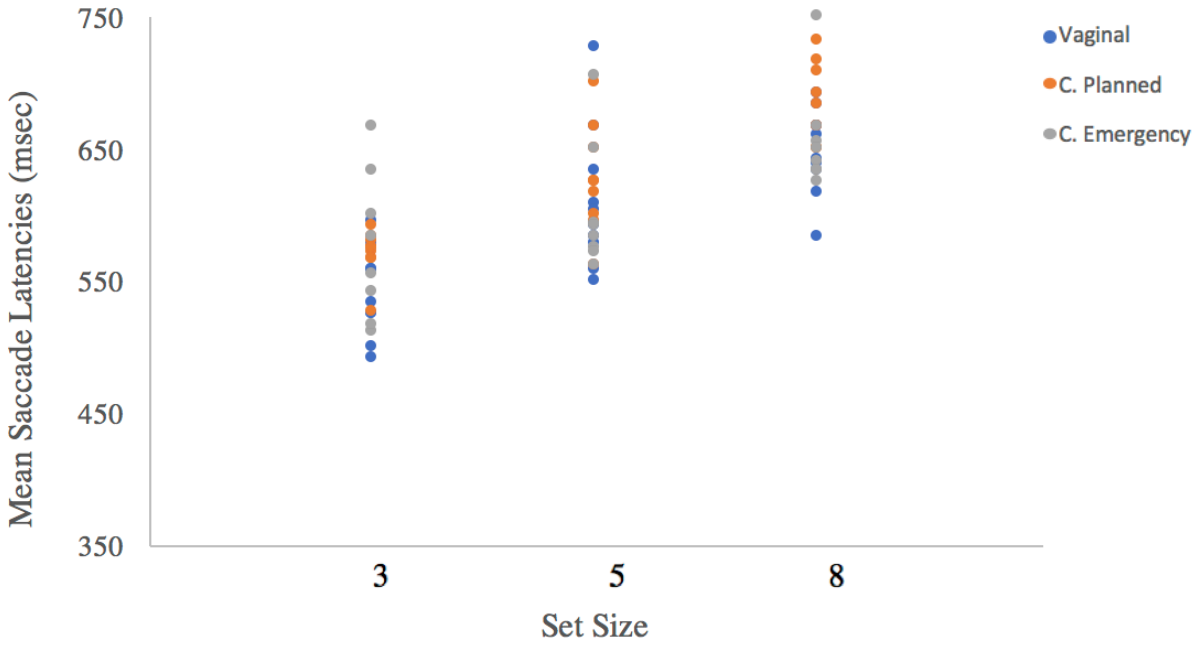

Fig 5. Feature-present (R) target display for individual participants. Each participants' mean target-directed saccade latencies for feature-present target condition plotted as a function of set size (3, 5, and 8 items) for each birth experience group. Each participant's trials per set sized were averaged. There was no evidence of outliers or nonnormality.

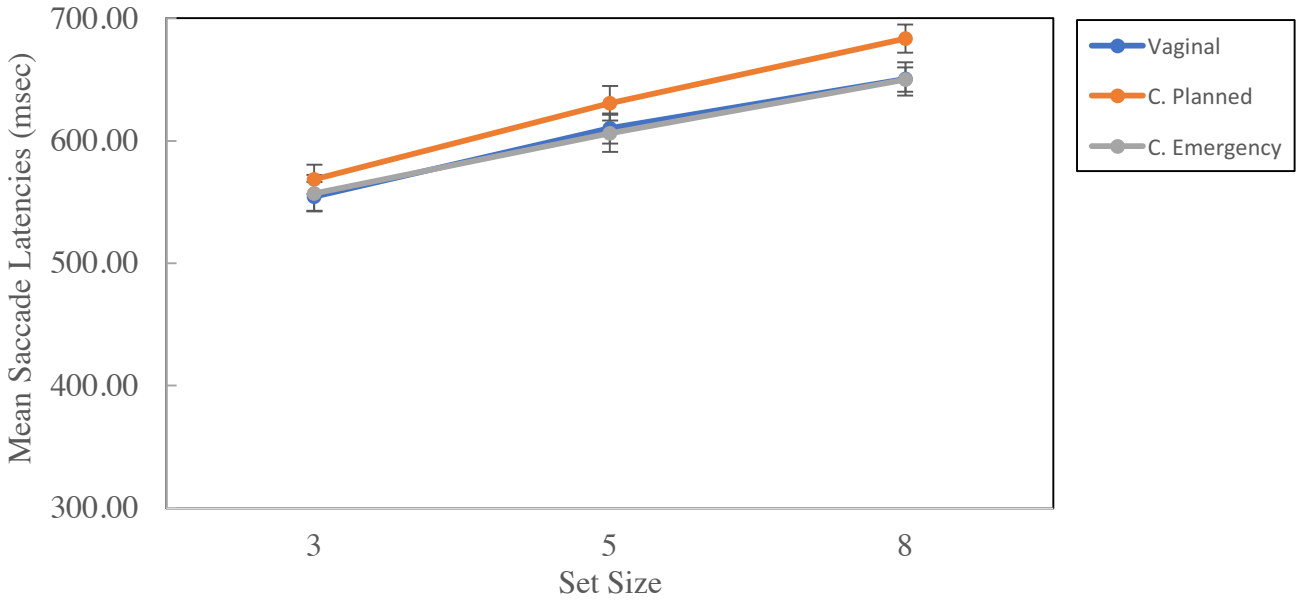

Fig 6. Feature-absent (P) target display. Mean target-directed saccade latencies for feature-absent target condition plotted as a function of set size (3, 5, and 8 items) for each birth experience group. As set size increased, so did the mean saccade latencies. The birth groups did not significantly differ in their mean saccade latencies for each set size. Error bars indicated +/- SE.

The interaction of set size and target condition from the original 3 x 3 x 2 omnibus ANOVA was also significant, $F(2, 383) = 16.27$, $p < .001$, $\eta_p^2 = .08$, indicating that depending on the array set size, infant saccade latencies were significantly different for the two feature-present and feature-absent arrays. This interaction was further analyzed by controlling for each set size in order to determine differences. Three separate one-way ANOVA tests were conducted to determine whether each set size had significant differences in mean saccade latencies when locating a feature-present or feature-absent target. A significant main effect was shown for a set size of 3, $F(1,140) = 11.8$, $p < .001$, $\eta_p^2 = .08$, set size of 5, $F(1,139) = 49.4$, $p < .001$, $\eta_p^2 = .26$, and set size of 8, $F(1,116) = 93.2$, $p < .001$, $\eta_p^2 = .45$. Infants across all birth groups and different set sizes were significantly slower at locating a feature-absent condition as opposed to a feature-present condition (see Fig. 4 & 6). To further explore this interaction, each target condition was

controlled for separately with comparisons using two separate one-way ANOVAs allowed to isolate each target condition type. A significant main effect was revealed for feature-absent target conditions, $F(2,191) = 38.1$, $p < .001$, $\eta_p^2 = 29$, suggesting that the mean saccade latencies of infants were significantly different across set sizes (see Fig. 6). Using the Tukey HSD post hoc comparisons, mean saccade latencies for feature-absent arrays revealed significant differences among the set sizes of 3 ($M = 560.47$), 5 ($M = 613.53$), and 8 ($M = 659.94$), $p < .001$. The second one-way ANOVA revealed no significant differences, $F(2,204) = 0.4$, *n.s.,* in mean saccade latencies between the different set sizes for feature-present target conditions (see Fig. 4). These findings demonstrate that irrespective of set size, infant target-directed saccade latencies did not increase with increasing set size for feature-present arrays. In contrast, infant saccade latencies for feature-absent arrays increased as set size increased. Consistent with previous findings (Adler & Gallego, 2014), the results suggest that infants exhibit the same asymmetry, with an efficient search for a feature-present target but an inefficient search for a feature-absent target, as adults (Boutsen & Marendaz, 2001; Levin & Angelone, 2001; Royden et al., 2001; Shen & Reingold, 2001; Treisman & Gormican, 1988; Treisman & Souther, 1985). Each participants' individual mean saccade latencies were also examined in feature-absent target-conditions to determine if any specific set of trials were outliers. Means of each participants' eye movements per set size in feature-absent condition were similar with means grouped (see Fig. 7).

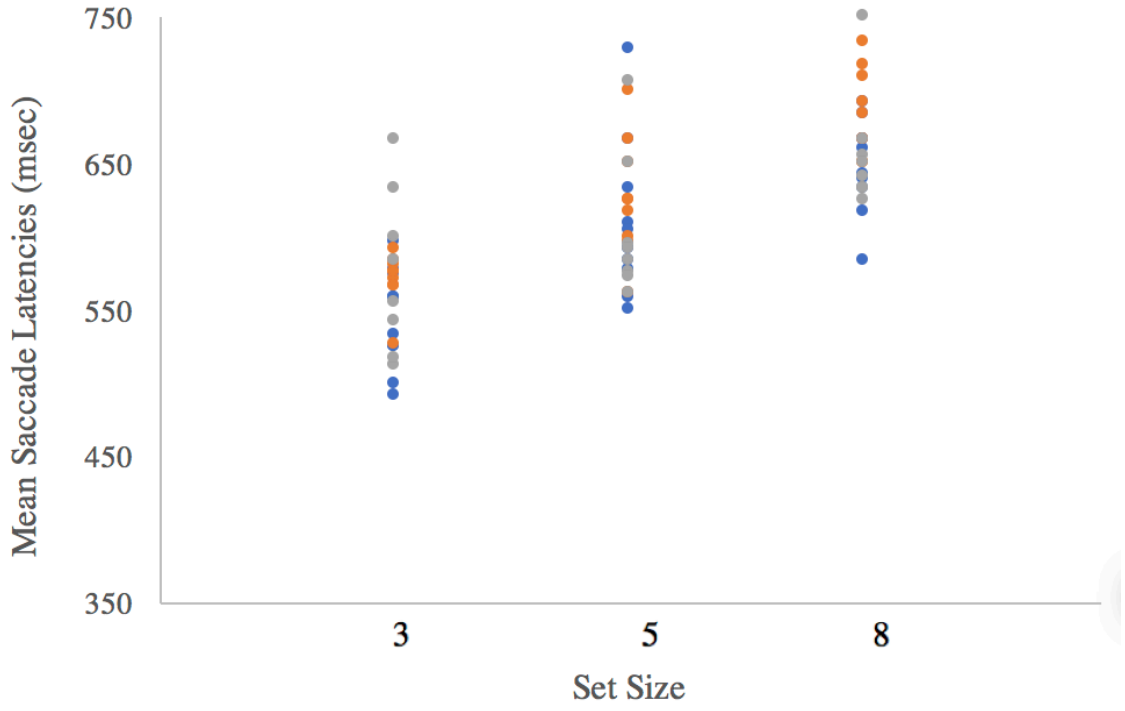

Fig 7. Feature-absent (P) target display for individual p. Each participants' mean target-directed saccade latencies for feature-absent target condition plotted as a function of set size (3, 5, and 8 items) for each birth experience group. Each participant's trials per set sized were averaged. There was no evidence of outliers or nonnormality.

Finally, the original 3 x 3 x 2 ANOVA also revealed nonsignificant interactions between birth experience and set size, $F(4, 383) = 0.90$, *n.s.*, as well as between birth experience, set size, and target condition, $F(4, 383) = 0.20$, *n.s.*, indicating that regardless of birth type infant saccadic latencies did not significantly differ for the different set sizes across either target condition.

In sum, these analyses suggest that all infants, irrespective of birth experience, exhibited an asymmetry with an efficient search for a feature-present target but an inefficient search for a

feature-absent target. Birth experience, however, did impact the speed at which attention was deployed in the feature-present target search, with infants born by a planned caesarean section being slower than infants with either of the two other birth experiences.

Regression of Latencies

Though the previous analyses provide information regarding the differences between variables, they do not assess whether or not efficient or inefficient searches were exhibited by any of the birth experience groups. Because determination of the efficiency of a search, and thus of the underlying responsible attentional mechanisms, is based on the nature and slope of the RT (or latency) x set size function, regression analyses were run on saccade latencies for each birth experience and target condition as a function of set size. In these regression analyses, the mean saccade latencies were the dependent variable, and birth experience group and set size were the independent variables. With feature-present arrays, the analysis revealed a nonsignificant relation for infants born in any manner, vaginally, $r^2 = .03$, *n.s.*, planned-caesarean section, $r^2 = .03$, *n.s.*, or emergency-caesarean section, $r^2 = .02$, *n.s.*, indicating that mean saccade latencies for each group were independent of set size (see Fig. 4). This finding was further supported by relatively flat slopes for the regression lines of 4.38 msec per item for infants born vaginally, 1.08 msec per item for planned-caesarean section, and 5.75 msec per item for those via emergency-caesarean section. These results and slopes are the consistent with previous research (Adler & Orprecio, 2006; Adler & Gallego, 2014) where feature-present target arrays elicit an efficient search resulting in target pop-out irrespective of the number of distractors in the array.

In contrast, with feature-absent arrays, regressions revealed significant relations for vaginal, $r^2 = .25$, $p < .001$, planned-caesarean section, $r^2 = .39$, $p < .001$, and emergency-caesarean section, r^2

= .20, $p < .001$, delivered infants indicating that as set size increased so did mean saccade latency (see Fig. 6). Furthermore, the slopes of the regression line were 48.01 msec per item for vaginal infants, 57.40 msec per item for planned-caesarean section, and 46.45 msec per item for emergency-caesarean section. These regression slopes suggest that each birth experience group exhibited an inefficient search with feature-absent target arrays, consistent with previous infant findings (Adler & Gallego, 2014). The regression results are indicative that infants' search, irrespective of birth experience, was asymmetrical where localization of a feature-absent target among feature-present distractors was relatively inefficient whereas the localization of a feature-present target among feature-absent distractors was fairly efficient.

EXPERIMENT 2: Search Asymmetry in Adults

Methods

Participants

Thirty adults, ranging from 17 to 27-years-old (9 males, 21 females), were recruited from the York University Research Pool. The adults participated in the experiment to obtain course credit. Prior to participation, participants were asked to complete a consent form and a brief demographic information sheet. All participants were naïve to the experimental purposes of the study. Each of the 3 difference birthing groups consisted of 10 participants. The adults in this sample were African ($n = 4$), East Asian ($n = 4$), Caucasian ($n = 6$), Hispanic ($n = 2$), Middle Eastern ($n = 6$), and South Asian ($n = 8$). Data from thirty adults were randomly selected for each birth experience group from the adults who participated and formed the final sample. Data from adults were excluded if there was failure in testing equipment ($n = 4$) or inattentiveness ($n = 3$).

Stimuli and Apparatus

The stimuli and apparatus remained the same as those in Experiment 1. The one exception was that adults were seated in front of the computer monitor resting their chin on an adjustable chinrest approximately 48 cm from the monitor. The visual angles and timings of the stimuli, and the set size and target locations target conditions, remained the same as in the first experiment. To equate recorded eye-tracker values of eye location to known locations on the screen, calibration of the eye-tracker was completed by having adults fixate nine concentric squares at fixated locations on the LCD monitor. The calibration values were used to filter all subsequently recorded eye-tracker data.

Procedure

The experiment had identical procures as Experiment 1, with the exception that adults were given some minimal verbal instructions on how to properly perform the task. Adults are told that they will be seeing a visual array and are required to make an eye movement to the item that is different. To ensure a fair comparison between the infants and the adults, no further instruction was provided to the adult participants prior to commencement of the experiment regarding the nature of the target, the different types of search arrays, or the set sizes. When presented with the array, consequently, the adults had no specific target in mind and not conducting a true search. Adults were tested with the same number of trials as infant participants.

Data Reduction and Analysis

The raw data will be digitally recorded and analyzed in the same manner as in Experiment 1. To determine the validity of eye movement, an initial velocity threshold was set for infant eye movements at 30 degrees/second setup as a derivative for distance from fixation to target location. Due to their ability to make faster reactive eye movements (Adler et al., 2002), the latency cut-off for adults will be 100 msec after the onset of the target array. Similar to infants, saccade latencies were pooled based on set size in each birth experience group.

Similar to infant results, to rule out the possibility that a select few of adults were responsible for skewing group means for each condition by set size, histograms were examined with outlier detection. All histograms also revealed similar distributions for groups by set size and condition. Though not included here, please see Table 2 in Appendix for the standard error of each group by condition. As evident by the standard error, there was no violation of heterogeneity of variance. Together these measures provide evidence that group means were not due to a select few adults.

Results

Preliminary Analysis

As in Experiment 1, mean saccade latencies to an R and P target condition, with a set size of 1, were compared to ensure that there were no differences simply due to reaction as a function of target type and birth experience to stimulus onset. A 2 x 3 x 4 ANOVA was conducted with target condition (R and P) and target location (3, 6, 9, and 12 o'clock) as within factors, and birthing group (vaginal, caesarean emergency, and caesarean planned) as a between factor. Target location was again analyzed to ensure there we no horizontal or vertical looking biases.

The analysis revealed that the main effect of target condition was not significant, $F(1, 715) = 2.92$, *n.s*., demonstrating the lack of a substantial difference between the saccade latencies made to an R ($M = 230.95$) and P ($M = 240.41$) targets. The main effect of birthing group, $F(2, 715) = 0.31$, *n.s*., and the interaction between the birthing group and target condition, $F(2, 715) = 0.47$, *n.s*., were also not significant. No significant differences were revealed between mean saccade latencies of adults born vaginally ($M = 237.17$ msec), via caesarean-section emergency ($M = 237.28$ msec), and caesarean section planned ($M = 232.38$ msec) when comparing mean saccade latencies of both feature-present and feature-absent target conditions with a set size of 1, *n.s*. The different birth groups, therefore, exhibit similar mean saccade latencies when only 1 item is displayed indicating that the ability to make a saccade to the onset of a target without the presence of competing distractors is equivalent for each group. Further, any differences in saccade latencies exhibited to feature-present and feature-absent target search arrays with set sizes greater than 1 could not be the consequence of an inherent performance of differentiating between the two stimulus characters, regardless of the birthing group.

Both the main effect of target location, $F(3, 715) = 0.37$, *n.s*., and the interaction of target condition and target location, $F(3, 715) = 0.12$, *n.s*., were not significant. No significant differences were found in the interaction of group and location, $F(6, 715) = 0.18$, *n.s.* This suggests that any differences in saccade latencies between birth types could not be due to differences in attentional allocation based on target location. The interaction of birth group, target condition and location was also not significant, $F(6, 715) = 0.33$, *n.s.,* suggesting that any differences in saccade latencies between groups could not be due to differences in attentional allocation based on target location. Thus, the location of the stimulus target did not result in any differences in saccade latencies. These findings indicate that if differences between saccade

latencies to an R vs a P search target with arrays emerge with set sizes greater than 1, they could not be due to any differences as a consequence of target location within the array. Consequently, data for all future analyses were collapsed across location.

Saccade Latencies as a Function of Set Size

To investigate whether birth experience still influenced attentional mechanisms as adults, the mean saccade latencies produced by each birthing group were compared across the 3 different set sizes. Consequently, as in Experiment 1, a 3 x 3 x 2 ANOVA was conducted on adults' mean saccade latencies as a function of birth experience (vaginal, caesarean emergency, and caesarean planned) as a between factor, and set size (3, 5, 8) and target condition (feature-present and feature-absent) as within factors. A significant main effect was found for birth experience, $F(2, 1509) = 13.23$, $p < .001$, $\eta_p^2 = .02$, indicating that irrespective of set size or target condition, adult target-directed saccade latencies were significantly different among the birth groups. Tukey's HSD post hoc tests comparing the mean saccade latencies of the birth groups revealed significant differences between vaginal ($M = 476.10$) and both emergency caesarean-section ($M = 507.40$) and planned caesarean-section infants ($M = 516.38$), $p < .001$. A nonsignificant difference, however, was found between planned and emergency caesarean-section.

A significant main effect was also revealed for set size, $F(2, 1509) = 12.95$, $p < .001$, $\eta_p^2 = .02$, indicating a significant difference in adult saccade latencies among the set sizes independent of the birth group or target condition. Post hoc comparisons revealed significant differences in latency for a set size of 3 ($M = 478.94$) when compared to 5 ($M = 502.05$) and 8 ($M = 521.74$), $p < .05$. Saccade latencies for a seet size of 5 also significantly differed from a set

size of 8, p <.001. The main effect of target condition was also significant, $F(1, 1509) = 138.25$, $p < .001$, $\eta_p^2 = .08$, demonstrating that saccade latencies to feature-present target arrays (M = 459.24) were significantly faster than those to feature-absent target arrays (M = 539.01), irrespective of either set size or birth experience, $p < .001$. These results suggest that localization of a feature-present target is efficient whereas localization of a feature-absent target is inefficient.

The interaction of birth group and set size was not significant, $F(4, 1509) = 0.05$, *n.s.*, whereas the interaction of birth group and target condition was significant, $F(2, 1509) = 5.58$, $p < .01$, $\eta_p^2 = .01$. These results indicate that the saccade latencies between the various birth groups were different for each of the target conditions but not a s function of set size. The significance of birth group and target condition was additionally analyzed by controlling for each birth experience. Three separate one-way ANOVA tests were conducted to determine whether each birth group had significant differences in mean saccade latencies when locating a feature-present vs a feature-absent target. A significant main difference was shown for infants born vaginally, $F(1,554) = 91.2$, $p < .001$, $\eta_p^2 = .14$, via planned caesarean-section, $F(1,409) = 25.0$, $p < .001$, $\eta_p^2 = .06$, and emergency caesarean-section, $F(1,558) = 27.7$, $p < .001$, $\eta_p^2 = .05$. To further explore the interaction between birth experience and target condition, target condition was isolated using two separate one-way within factors ANOVAs were conducted for each target condition. For feature-present target conditions, the ANOVA was significant, $F(2,744) = 16.07$, $p < .001$, $\eta_p^2 = .04$, suggesting a significant difference in mean saccade latencies of the different birth types (see Fig. 8). Tukey HSD post hoc tests indicated that mean saccade latencies to feature-present target arrays for vaginally born infants (M = 425.49) were significantly faster than those born by either planned (M = 484.24) or emergency caesarean-section (M = 476.98), $p < .001$, though planned did not differ from emergency caesarean-section infants. Each adult

participants' individual mean saccade latencies were examined to determine if any specific set of trials were outliers and cause of skewing group means. Means of each participants' eye movements per set size in feature-present condition were similar with means grouped (see Fig. 9).

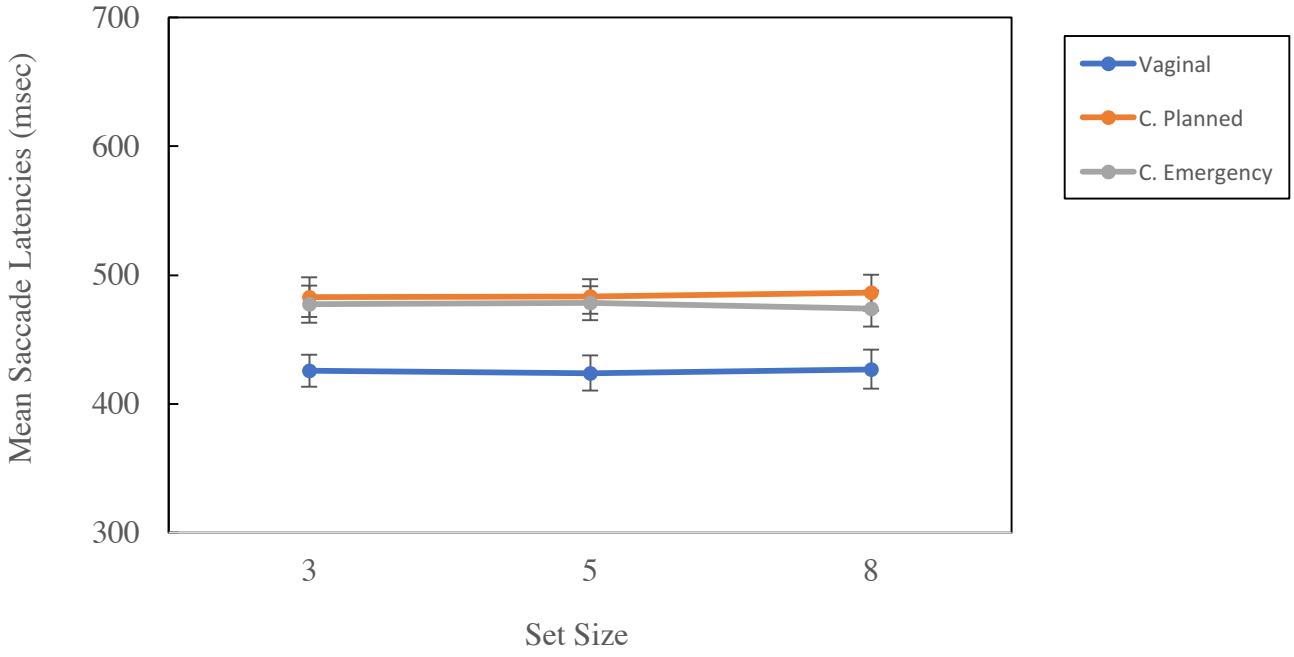

Fig. 8 Feature-present (R) target display. Mean target-directed saccade latencies for feature-present target condition plotted as a function of set size (3, 5, and 8 items) for each birth experience group. Independent of set size, mean saccade latencies remained the same. Vaginally born adults performed significantly faster than planned and emergency caesarean-section infants. Error bars indicated +/- SE.

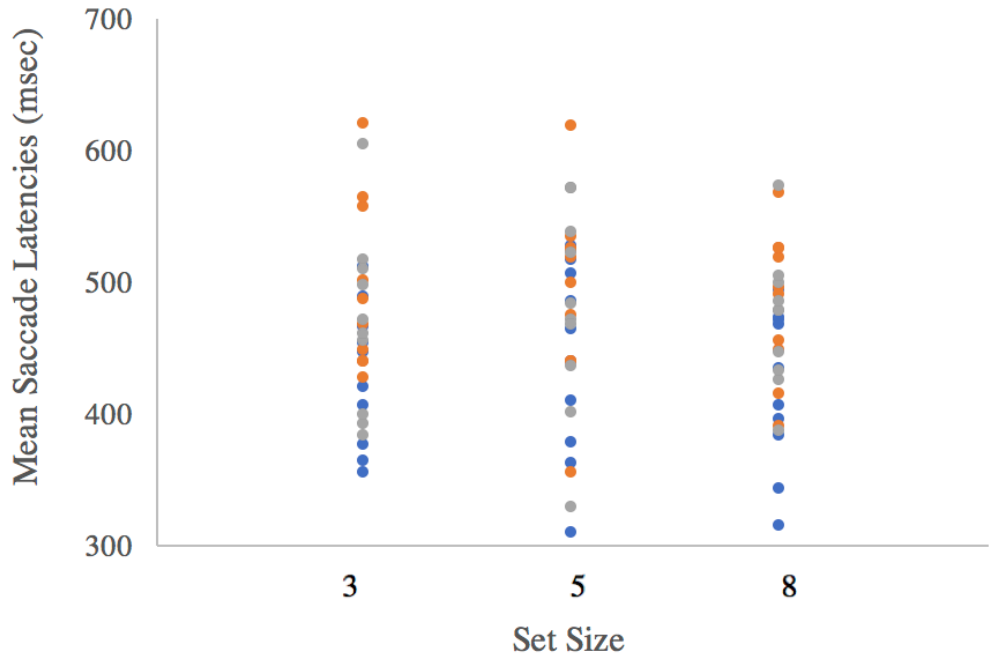

Fig 9. Feature-present (R) target display for individual adult participants. Each participants' mean target-directed saccade latencies for feature-present target condition plotted as a function of set size (3, 5, and 8 items) for each birth experience group. Each participant's trials per set sized were averaged. There was no evidence of outliers or nonnormality.

For feature-absent target conditions, the second ANOVA was nonsignificant, $F(2,747) = 0.59$, *n.s.,* indicating no significant differences in mean saccade latencies between the different birth types, (see Fig. 77). In contrast to the infant results in Experiment 1 in which vaginally born infants and emergency caesarean-section infants' mean saccadic latencies did not significantly differ, saccade latencies for vaginally born adults were faster than mean saccade latencies for both groups of caesarean-section adults. These results indicate that the effects of birth experience on target-directed saccade latencies persist into adulthood.

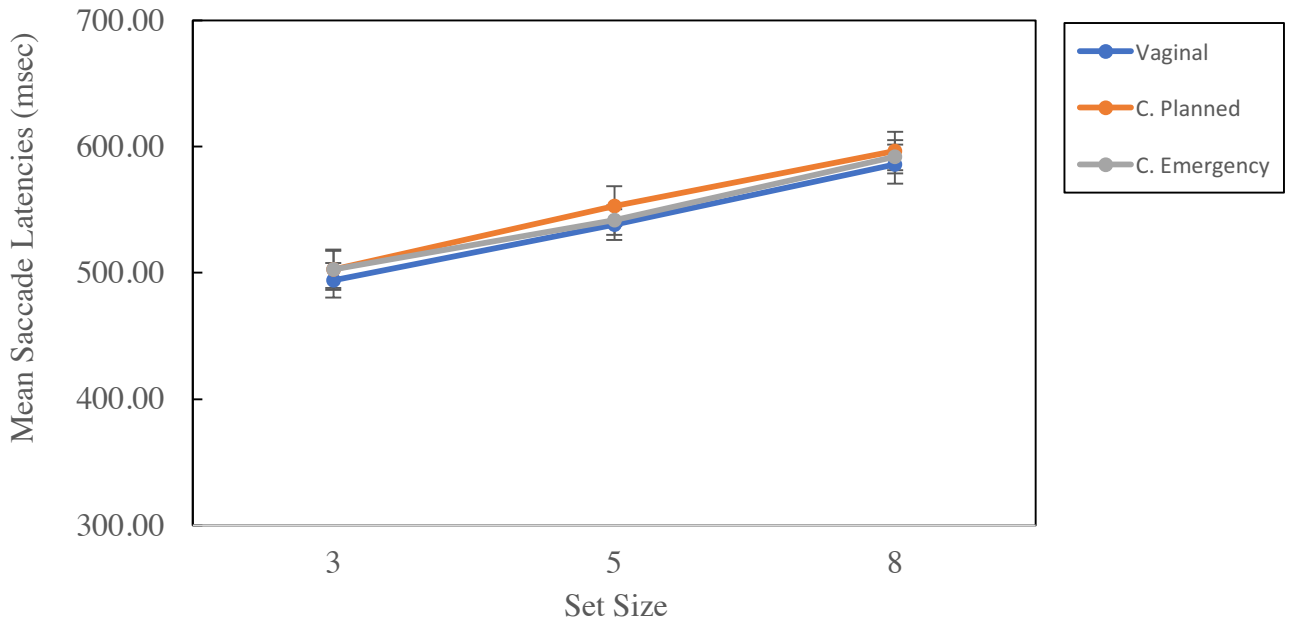

Fig. 10 Feature-absent (P) target display. Mean target-directed saccade latencies for feature-absent target condition plotted as a function of set size (3, 5, and 8 items) for each birth experience group. As set size increased, so did the mean saccade latencies. The birth groups did not significantly differ in their mean saccade latencies for each set size. Error bars indicated +/- SE.

The interaction of set size and target condition in the original 3 x 3 x 2 omnibus ANOVA was also significant, $F(2, 1509) = 14.44$, $p < .01$, $\eta_p^2 = .02$, demonstrating that saccade latencies across set sizes were significantly different in each of the two target conditions. To further analyze this interaction, birth experience was controlled for and isolated. Three separate one-way ANOVA tests were conducted to determine whether each set size had significant differences in mean saccade latencies when locating a feature-present or feature-absent target. A significant main effect was shown for a set size of 3, $F(1,582) = 11.9$, $p < .001$, $\eta_p^2 = .02$, set size of 5, $F(1,537) = 57.9$, $p < .001$, $\eta_p^2 = .10$, and set size of 8, $F(1,402) = 120.4$, $p < .001$, $\eta_p^2 = .23$. Adults across all birth groups and set sizes were significantly faster at locating a feature-present condition as opposed to a feature-absent condition. Further comparisons for the interaction

between set size and target condition were conducted by controlling for target condition using two separate one-way ANOVAs to isolate each target condition. For feature-absent target conditions, a significant main effect was revealed for set size, $F(2,747) = 28.63$, $p < .001$, $\eta_p^2 = .07$, suggesting significant differences in the mean saccade latencies of adults in when comparing set sizes (see Fig. 10). Post hoc comparisons using the Tukey HSD test indicated significant differences in feature-absent target conditions between a set size of a set size of 3 ($M = 499.76$) compared to 5 ($M = 543.49$) and 8 ($M = 591.35$), $p < .001$. For feature-present target conditions, the second one-way ANOVA revealed no significant differences, $F(2,774) = 0.01$, *n.s.*, in mean saccade latencies between the different set sizes (see Fig. 8). Similar to infants, the findings demonstrate that irrespective of set size, adult target-directed saccade latencies did not increase with increasing set size for feature-present arrays, however increasing set size did increase target-directed saccade latencies in present-absent arrays. Again, as with the infants in Experiment 1 and consistent with previous findings (Adler & Gallego, 2014; Boutsen & Marendaz, 2001; Levin & Angelone, 2001; Royden et al., 2001; Shen & Reingold, 2001; Treisman & Gormican, 1988; Treisman & Souther, 1985), the results suggest that adults exhibit the same asymmetry, with an efficient search for a feature-present target but an inefficient search for a feature-absent target. Each participants' individual mean saccade latencies for feature-absent target conditions were also examined to determine if any specific set of trials were outliers. Means of each participants' eye movements per set size in feature-absent target condition were similarly grouped per birth experience (see Fig. 11).

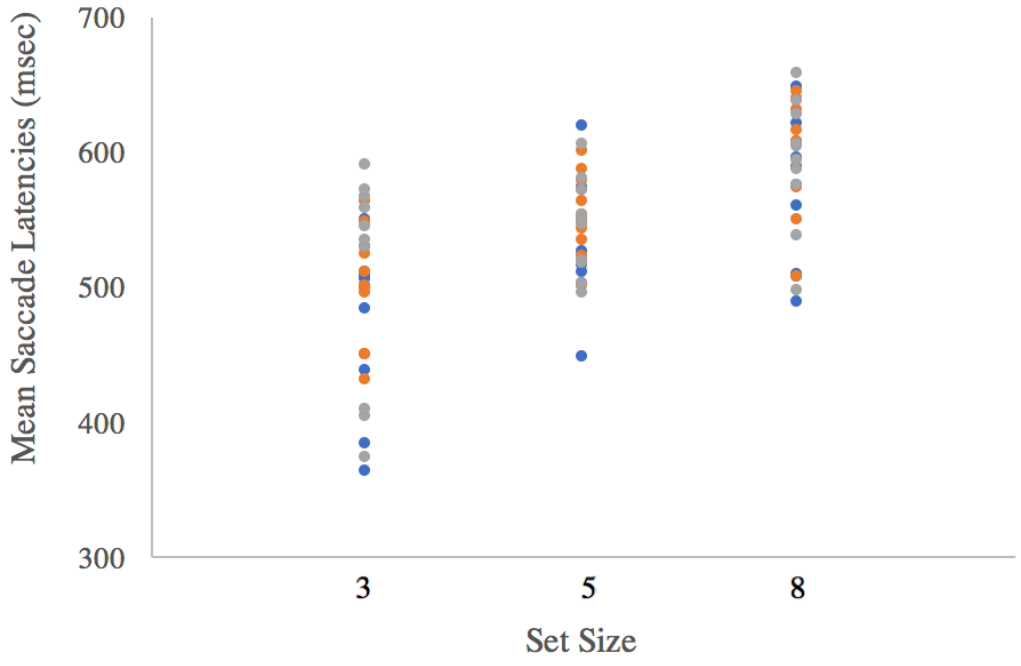

Fig 11. Feature-present (P) target display for individual adult participants. Each participants' mean target-directed saccade latencies for feature-absent target condition plotted as a function of set size (3, 5, and 8 items) for each birth experience group. Each participant's trials per set sized were averaged. There was no evidence of outliers or nonnormality.

Finally, the original 3 x 3 x 2 ANOVA also revealed a nonsignificant interaction between birth experience, set size, and target condition, $F(4, 1509) = 0.03$, *n.s*. All of these results, congruent with those found with infants and consistent with the previous study using this paradigm (Adler & Gallego, 2014) as well as with the adult visual search literature (Nagy & Cone, 1996; Royden, Wolfe & Klempen, 2011; Treisman & Souther, 1985), suggest a search asymmetry in that target-directed saccade latencies to feature-present arrays did not change with increasing set size indicative of an efficient search, whereas to feature-absent arrays mean

saccade latencies increased as set size increased indicative of an inefficient search. Furthermore, these results reveal that the effect of birth experience on the speed at which attention was allocated to feature-present target arrays seems to be permanent, persisting from infancy to adulthood. Yet, the adults differed from the infants in that emergency caesarean sections who showed no impact of that birth experience relative to vaginal delivery as infants, now did so as adults.

Regression of Latencies

As with the infants in Experiment 1, though the previous analyses provide information regarding the differences between variables, they do not assess whether or not efficient or inefficient searches were exhibited by any of the adult birth experience groups. Regression analyses with the mean saccade latencies as the dependent variable and birth experience group along with set size as the independent variables was conducted. For feature-present arrays, the analysis revealed a nonsignificant regression for each of the three adult birth experience groups of vaginal, $r^2 = .01$, *n.s.*, planned-caesarean section, $r^2 = .01$, *n.s.*, and emergency-caesarean section, $r^2 = .01$, *n.s.*, indicating mean saccade latencies remained unaffected by increasing set size for all birth experience groups (see Fig. 8). Further supporting the lack of a relation, the slopes of the regression lines were relatively flat at 0.61 msec per item for adults born vaginally, 1.68 msec per item for planned-caesarean section, and -1.79 msec per item for those via emergency-caesarean section. Consistent with infants in Experiment 1 and previous findings (Adler & Orprecio, 2006; Adler & Gallego, 2014), these findings show that, although preceding analyses indicated significant differences between the different birth experience groups with feature-present target arrays, each group exhibited an efficient search in localizing the feature-present target irrespective of the number of distractors.

In contrast, significant regressions were revealed for feature-absent arrays for adults born vaginally, $r^2 = .07$, $p < .001$, via planned-caesarean section, $r^2 = .07$, $p < .001$, and emergency-caesarean section, $r^2 = .06$, $p < .001$, indicating that mean saccade latencies increased with increasing set size for each birth experience group (see Fig. 10). This effect is substantiated as the slopes of each regression line were 45.99 msec per item for adults born vaginally, 46.92 msec per item for planned-caesarean section, and 44.54 msec per item via emergency-caesarean section. These regression slopes, consistent with the infants in Experiment 1and previous adult findings with this paradigm (Adler & Gallego, 2014; Adler & Orprecio, 2006; Chan & Hayward; 2013), suggest that each birth experience group exhibited an inefficient search of feature-absent target arrays. The regression results are indicative that adults' search, irrespective of birth experience, was asymmetrical where localization of a feature-present target among feature-absent distractors was relatively efficient whereas the localization of a feature-absent among feature-present distractors was inefficient.

GENERAL DISCUSSION

Early influences on development as a result of environmental factors and experiences have been shown to sometimes have long-term effects (Greenough & Black, 2013; Maurer, Ellemberg, & Lewis, 2006; Mohades et al., 2012; Quigley et al., 2012), yet the influence of the earliest experience, that of birth, on brain structures and the development of cognitive processes such as selective attention has been overlooked. The experience of birth, particularly caesarean-section, has been suggested by previous research to impact stimulus driven, bottom-up processing, where reactive latencies were slowed relative to those of vaginally delivered infants (Adler & Wong-Kee-You, 2015). To confirm and extend that finding, the current study further investigated using a different visual attention paradigm allowing and a more in-depth comparison

of the different types of caesarean-section births to determine whether attention was impacted differently depending on the different birth experiences.

Understanding the development of selective attention, and all the factors that impact that development, is important due to attention's nature of highlighting particular items in a visual field and directing mechanisms to selectively focus resources on those particular items for further processing (Adler & Gallego, 2014; Driver, 2001; Posner & Peterson, 1990; Theeuwes, 2010). For infants, selective attention enables allocation of even more limited available resources (Dehaene-Lambertz & Spelke, 2015) to filter irrelevant and uninteresting information in the environment and allows them to be active in their own learning process (Adler, 2005; Adler & Gallego, 2014; Colombo et al., 1990; Rose, Feldman & Jankowski, 2004). Visual search tasks are particularly sensitive to the different components of attention, bottom-up and top-down, that determine search efficiency (Wolfe, 1998) and allow for a better understanding of attentional mechanisms. By using a visual search task with infants and adults in which a unique target needs to be selected from among simultaneously present multiple stimuli to better assess the different components of attention (Adler & Gallego, 2014), the current study and findings reveal how early experiences impact the development of those different attentional mechanisms.

Previous research has shown evidence that birth experience can alter initial brain functioning and result in differences in bottom-up attentional processing (Adler & Wong-Kee-You, 2015). Infant delivered via caesarean-section had slower stimulus-driven reactive latencies compared to vaginally delivered infants, however the cognitively driven, voluntary attention remained unaffected. In the present study, planned caesarean-section infants' stimulus-driven, reflexive attention was slowed compared to both vaginally delivered and emergency caesarean-section infants. There were no significant differences in localizing feature-present targets

between infants delivered vaginally and via emergency caesarean-section. In adult participants, on the other hand, both planned and emergency caesarean-section displayed slower stimulus-driven, reflexive attention compared to vaginally delivered adults. Regardless of planned or emergency caesarean-section, both groups were slower when localizing feature-present targets compared to those born vaginally. Differences in birth experience did not affect cognitively driven, voluntary attention in either infant nor adult participants. Consistent with the study by Adler and Wong-Kee-You (2015), the current study therefore demonstrates that the type of birth an individual experiences does impact bottom-up stimulus-driven attention, yet it does not seem to interact with top-down cognitively-driven attention in search mechanisms. The current findings also demonstrate that the influence of development of selective attention by early experiences persists into adulthood. This finding highlights the importance of understanding the implications of early experience on cognitive structures and to help better understand brain development, especially considering its persistence into adulthood.

Search Asymmetry in Infants and Adults

Past studies of visual search suggest that the presence or absence of a unique perceptual feature asymmetrically influences the allocation of attentional resources (Nagy & Cone, 1996; Royden, Wolfe & Klempen, 2011; Treisman & Gelade, 1980). A feature-present display engenders an efficient search whereby attentional processing is allocated in parallel to all items within the display and attentional resources are then automatically directed to the stimulus with the unique perceptual feature resulting in the latency and accuracy of locating the target are independent of the number of items present within the display (Julesz, 1984; Treisman & Souther, 1985; Treisman & Gormican, 1988; Wolfe et al., 2003). In contrast, a feature-absent stimulus engenders an inefficient search where the saccade latency and accuracy of locating the

target are dependent on the number of items present within the display (Treisman & Gelade, 1980; Treisman & Souther, 1985). Feature-absent search, therefore, relies more on the cognitively-driven, top-down processing in search mechanisms where resources need to attentively search the display item-by-item in order to locate the item (Krose & Julesz, 1989).

The Guided Search model provides a framework for understanding such search asymmetry effects by proposing that saliency signals are influenced due to the presence or degree of distinctiveness of stimuli perceptual features that determine the engagement of different levels of processing (Wolfe, 2001). Bottom-up processing guides attention to stimuli that stand out due to the saliency of a unique perceptual feature (Wolfe, 1994). When stimuli compete, or are in conflict with one another, however, as when the target is defined by the absence of a feature shared among distractors in the display, top-down processing is then involved due to the lack a strong saliency signal produced by the target (Wolfe, 1994; Wolfe, 2001). The GS model emphases the interaction between both bottom-up and top-down processing acknowledging a continuum of efficiency.

Examining search asymmetry in early infancy would potentially expose the respective development of bottom-up and top-down attentional mechanisms, which have been hypothesized to develop at different rates (Atkinson & Braddick 2011, Atkinson 2000, Scerif & Amos, 2015). Early infant search asymmetry studies, using preferential looking, have revealed that infants as young as 3 to 4 of age look longer at a display that contains a feature-present target compared to a homogenous display that does not, suggesting an ability to detect a unique stimulus defined by the presence of a feature (Colombo et al., 1995). Later studies using kicking rate as the dependent measure demonstrated the possible existence of a search asymmetry in that 3-month-old infants discriminated a feature-present mobile, but not a feature-absent mobile, from a

homogeneous mobile (Adler et al., 1998). These studies suggest that search asymmetry and the underlying attentional mechanisms are functioning in early infancy, but these studies suffer in that their timing is too long and there is a lack of a set size analysis to properly diagnose the existence of a search asymmetry and its underlying attentional mechanism (Adler, 2005; Adler & Orprecio, 2006; Adler & Gallego, 2014). To this end, more recent evidence of asymmetric eye movement differences in target localization as a function of set size and timings on the same order as found in adult search studies further support the notion that infants not only allocate attention through bottom-up processing, but also through cognitively drive, top-down processing similar to that of adults (Adler & Gallego, 2014).

Interestingly, the slowed stimulus-driven, reflexive attention as a result of caesarean-section delivery did not impact the asymmetrical effects for feature-present and feature-absent target conditions in infants or adults. The results revealed, that regardless of birth experience, localization of a feature-present target with increasing set size was not influenced, whereas localization of feature-absent targets was slowed with an increasing number of distractors on the display. The results suggest that the underlying mechanisms, both top-down and bottom-up, remain intact, consistent with previous search asymmetry studies (Adler & Gallego, 2014; adult refs). Instead, the different birth experiences seem to impact the speed at which bottom-up attention, or determination of the saliency signals is processed, thus slowing the allocation of the bottom-up attention and consequently the reactive saccadic eye movements.

Processes of Birth Experience and Attentional Development

Though birth is one of the earliest experiences any of us has and early experiences are known to impact cognitive development (Aoki & Erisir, 2013; Diamond & Amso, 2008;

Greenough & Black, 2013; Maurer, Ellemberg, & Lewis, 2006), besides the recent study of Adler and Wong-Kee-You (2015), there has been no research in to the impact of birth itself on cognitive development. In the present study, therefore, saccadic eye movements of infants and adults were mapped and analyzed in an attempt to measure the development of attention as related to a more refined delineation of birth experiences. Findings indicated that emergency caesarean-section infants perform similarly to those delivered vaginally and are significantly faster than planned caesarean-section infants. With development into adulthood, this effect disappears and both caesarean-section birth types become significantly slower at localizing a feature-present target.

Two theories, "birth process" (Toda et al., 2013) and "bacterial baptism" (Polidano, 2017), have been proposed as mechanisms that due to caesarean-section birth relative to vaginal birth might inform the effects seen in the current study. The "bacterial baptism" theory proposes that differences in birth experience as a consequence of physically passing through the vaginal canal initiates the seeding of the neonate's gut microbiome (Cryan & Dinan, 2012; Galland, 2014). Infants are initially exposed to bacteria either through the mother's vaginal canal, if they are born vaginally (Bezirtzoglou, 1997), or from the surfaces they initially make contact with such as healthcare providers, hospital environment and, particularly, their mother's skin, if they are born via caesarean-section (Bezirtzoglou, 1997; Gronlund et al., 1999, Polidano, 2017). The proper functioning of the gut microbiome has been shown to have wide ranging influences on the body's functioning and development, including brain development (Borre, Moloney, Clarke, Dinan, & Cryan, 2014). For example, research has linked brain functioning and its development to the functioning of the gut microbiome (Borre, Moloney, Clarke, Dinan, & Cryan, 2014; Collins, Surette, & Berick, 2012; Gareau, 2014). If the gut microbiome is disrupted in some

manner, as might occur due to caesarean birth, then brain development and its functions, such as attentional processing, might also be disrupted. In fact, differences in early cognitive development have recently been suggested to be related to differences in the gut microbiome of infants as a result of caesarean-section births (Polidano, 2017).

Alternatively, the "birth process" theory is illustrated by a study by Toda et al. (2013) revealed differences in the brain development of rat pups as a result of rat mothers being induced to give birth prematurely, causing an accelerated development in the barrel formation of rat pups postnatally. The process of being born (i.e., labour and traversing the birth canal) is thought to cause a decline in serotonin level, thereby triggering an accelerated development of those specific brain regions that use serotonin. In humans, the corresponding brain region to the rat's barrel formation is the somatosensory cortical region, which has been shown to be involved in reactive spatial attention (Balslev, Odoj, & Karnath, 2013; Jones et al., 2010). Infants who do not go through the birth process, such as those born by planned caesarean-section and therefore do not experience any labour, are likely to have some affects in the development of their visual attention mechanisms. On the other hand, infants that have experienced partial labour, such as those born by emergency caesarean-section, are theorized to have similar development of their visual attention mechanisms to those delivered vaginally. Experiencing partial labour, differentiating between planned and emergency caesarean-section births, could therefore potentially cause the significant difference in feature-present target localization perhaps due to the somatosensory cortex's involvement in bottom-up attention processing (Balslev, Odoj, & Karnath, 2013; Jones et al., 2010).

The study by Adler and Wong-Kee-You (2015) substantiated the predictions of these theories by showing that infants born by caesarean-section were slower to allocate attention and

make eye movements than infants born vaginally, but could not distinguish the relative validity of either theory. The current study further supports the idea of the caesarean birth impacting attention and its development by finding that infants born by planned caesarean-sections exhibited slower mean saccade latencies in the bottom-up attention mediated feature-present search than infants born vaginally and adults born by both planned and emergency caesarean-sections exhibiting slower latencies than those born vaginally. The current findings may go even further and demonstrate that both theoretical processes play a role in modulating attentional development.

That planned caesarean-section individuals exhibit the same impact of that birth as infants and adults, whereas emergency caesarean-section individuals exhibit an impact of that birth as adults but not as infants suggests that different processes are mediating the impact of these births on attention. The difference in the birth experience of these two types of caesarean-sections is that those born by emergency caesarean-section experience at least partial labour whereas those born by planned caesarean-section do not. Of the two theories, only the birth process framework includes labour as a parameter. Consequently, individuals born by a planned caesarean-section do not receive the benefit of the birth process which is then expressed as slower attentional allocation of bottom-up mechanisms as infants.

In contrast, the "bacterial baptism" theory does not differentiate between the two types of caesarean-section. Neither planned nor emergency caesarean-section individuals experience the birth canal and likely experience similar interactional environments after birth, leading to a disrupted seeding of their microbiome. The impact of the disrupted microbiome, which has its impact on brain development more slowly and over a longer time frame (Polidano, 2017), is not immediately apparent in infancy but becomes so by adulthood (and perhaps earlier). As a

consequence, slower bottom-up attentional allocation is not exhibited in the current study in emergency caesarean-sections, who do receive at least some aspect of the birth process boost, until adulthood.

Overall, as predicted, slower attentional allocation and eye movement initiation to feature-present target arrays were exhibited by those born by caesarean-section, substantiating previous findings (Adler & Wong-Kee-You, 2015). Furthermore, the current findings demonstrate that the effect of birth experience is not transient but persists into adulthood, likely due to permanent effects of the initial conditions for brain development. Interestingly, different patterns of effects were exhibited by the different types of caesarean-section birth experiences at the different ages. Adults born via both planned and emergency caesarean-sections did not significantly differ and both were significantly slower than vaginally born adults, whereas as for infants only those born by planned caesarean-sections were slower than those born vaginally. Infants delivered by emergency caesarean-sections, however, were not different from those delivered vaginally. While the "birth process" theory better explains the effects of birth experience in infants with differences between planned and emergency caesarean-section, the "bacterial baptism" theory better accounts for the longer term significant differences between vaginally born adults and both caesarean-section adult groups. Thus, the current findings seem to indicate that neither theory alone can account for the mechanism by which the birth experience influences attention and development but that the mechanisms encompassed by both theories provide a path by which early cognitive and brain development is influenced by multiple factors involved in birth experience but that they perhaps work over different time scales.

Theories of Attentional Development

The current findings also provide information regarding the development of the mechanisms that underlie selective visual attention. At its basic form, visual attention selectively filters all the information simultaneously available in the environment allowing for learning and memory processing to take place without too much interference (Desimone & Duncan, 1995; Petersen & Poser, 2012). Understanding the development of attentional mechanisms and the processes that are involved in the selective filtering of environmental information allows for a more in-depth explanation behind the general functioning of those mechanisms in adults as well as whether they are fully functioning in early stages of life. Some previous studies have theorized that cognitive development and visual processing, particularly visual attention, occurs in a step-like hierarchical organization where attentional development is more static and different mechanisms follow a set of rigid developmental timelines and become functional at specific ages (Johnson, 1990; Amso & Scerif, 2015). These studies propose that although relevant brain regions may already be developed, they do not become fully functional until a certain age period. Amso and Scerif (2015), for example, theorize that complex visual attention mechanisms responsible for orienting attention shifts, such as top-down executive functioning, do not become functional until about 4 to 6 months of age. The development of neural functions is proposed to be sequence-like, similar in all infants, followed by the associated behavioral change to that cognitive structure (Johnson, 1990). Consistent with the theories' timelines, infants exhibit an efficient search for a feature-present target based on functional bottom-up attentional processing of the target's unique salient feature. Inconsistent with the theories' timelines, the current study further demonstrates that infants locate a feature-absent target among feature-present stimuli in an inefficient search that is likely due to the competing nature of similar stimuli present in the

array (Krose & Julesz, 1989; Wolfe, 2001). That similar to adults, 3-month-old infants were capable of locating the feature-absent target suggest that some manner of top-down processing is functional at this age, which is earlier than suggested by attentional developmental theories (refs). It is, therefore, possible that these functions do exist at younger age ranges and are influenced based on experience.

Besides suggesting that the timeline of attentional developmental theories might not be accurate, contrary to the findings from these previous theories, the current study also suggests that attention can be more fluid and based on experience, for example, influenced by birth experience. Early infant experience, such as exposure to monolingual or bilingual environments, have shown to influence cognitive processing of infants as young as 6-months-old (Comishen, Bialystok, & Adler, 2019). That is, the experience of interacting and living in a complex environment in which more than one language is being spoken allowed infants for greater attentional control (Comishen et al., 2019). The current findings demonstrate that even earlier development factors such as being born by caesarean-section birth influence the use of bottom-up mechanisms, which are thought to be functional very early life, in infants as well as in adults suggests that this mechanism is not set and its development and final state is influenced by experience. Furthermore, that different types of caesarean-section birth produce different patterns of attentional performance in the search for a feature-present target at the different ages provides more evidence that attentional development is not static and rigid as proposed (Amso & Scerif, 2015; Johnson, 1990) but is instead fluid and influenced by experiences early in life.

Future Directions

There are a number of unanswered questions as well as alternative factors regarding the current findings. First, the relative impact of other early gestational and birth variables such as gestational age, drugs given during birth, specific reasons for caesarean-section including parents' ages and weight, etc. need to be assessed in order to rule out their possible influence on attentional differences presented by participants. All of these factors have been shown to influence development (Chu et al., 2007; Galtier-Dereure, Montpeyrouz, Boulot, Bringer, & Jaffiol, 1995; Barber et al., 2011; Menendez et al., 2000) and so need to be evaluated. Second, the delayed effect of slowed mean saccade latency in emergency caesarean-section from infancy to adulthood needs to be further analyzed by testing various age groups in the attempt to determine the developmental period at which the shift occurs. Determining the specific age or range at which those born by emergency caesarean-section become slower than those delivered vaginally can allow for a better understanding of its cause and its potential impact on other cognitive mechanisms. Third, the slowing of attentional allocation due to caesarean-section births may also impact other higher cognitive mechanisms. The impact on other brain development mechanisms associated with attention, such as memory strength, is unclear and needs to be further investigated. Finally, it may be noteworthy to further examine the possible role of birth experience on developmental disabilities. If caesarean-section births are resulting a slowed reflexive attention, it is important to explore its potential influence on developmental disabilities of attention, as with ADHD.

CONCLUSION

The aim of the current study was to investigate whether differences in birth experience influences performance on visual search tasks involving top-down goal-driven and bottom-up stimulus-driven attentional processing. The purpose of the study was to confirm previous results whether the functioning of stimulus-driven, bottom-up processing are affected in infants due to birth experience, while also investigating the theoretical relation between the developmental outcomes and birth experience. Replicating the same methodology and measures with adults and infants allowed for a more direct comparison and to determine the permanence of influences or impacts due to differences in birth experience. The current study showed differences in bottom-up, stimulus-drive, attentional processing due to different birth experience for both infant and adult participants, but did not find any effect on the top-down, goal-driven, processing in neither infants nor adult participants. Future studies can be completed to better understand the nature of these changes and the reason behind the long-term impact of one theory versus the other. The ability to understand the full capacity of visual attention and developmental cognitive changes at a sensitive time period, specifically with infants and their limited processing resources, is important as it can be used to aid their construction and learning of stimuli continuously presented in their environment.

REFERENCES

Adler, S.A. (2005). Visual search and pop-out in infants. In L. Itti, G. Rees, & J. K. Tsotsos (Eds.), *Neurobiology of attention*. London: Elsevier Academic Press.

Adler, S. A., Bala, J., & Krauzlis, R. J. (2002). Primacy of spatial information in guiding target selection for pursuit and saccades. *Journal of Vision, 2*(9), 5.

Adler, S.A., & Gallego, P. (2014) Search asymmetry and eye movements in infants and adults. *Attention, Perception, & Psychophysics*, 76, 1590-1608.

Adler, S. A., & Haith, M. M. (2003). The Nature of Infants Visual Expectations for Event Content. *Infancy,4*(3), 389-421. doi:10.1207/s15327078in0403_05

Adler, S. A., Haith, M. M., Arehart, D. M., & Lanthier, E. C. (2008). Infants' visual expectations and the processing of time. *Journal of Cognition and Development*, 9, 1-25.

Adler, S. A., Inslicht, S., Rovee-Collier, C., & Gerhardstein, P. C. (1998). Perceptual asymmetry and memory retrieval in 3-month-old infants. *Infant Behavior and Development, 21*(2), 253-272.

Adler, S. A., & Orprecio, J. (2006). The eyes have it: Visual pop-out in infants and adults. *Developmental Science, 9*(2), 189-206.

Adler, S. A., & Wong-Kee-You, A. M. (2015). Differential attentional responding in caesarean versus vaginally delivered infants. *Attention, Perception, & Psychophysics, 77*(8), 2529-2539.

Amso, D., & Scerif, G. (2015). The attentive brain: Insights from developmental cognitive neuroscience. *Nature Reviews Neuroscience, 16*(10), 606-619. doi:10.1038/nrn4025

Aoki, C., & Erisir, A. (2014). Experience-Dependent Synaptic Plasticity in the Developing Cerebral Cortex. *The Synapse,* 397-445. doi:10.1016/b978-0-12-418675-0.00013-4

Atkinson, J. (1984). Human visual development over the first 6 months of life. A review and a hypothesis. *Human Neurobiology*, 3, 61-74.

Atkinson, J. (2000). *The developing visual brain*. Oxford: Oxford University Press.

Balslev, D., Odoj, B., & Karnath, H. (2013). Role of Somatosensory Cortex in Visuospatial Attention. *Journal of Neuroscience,33*(46), 18311-18318.

Bezirtzoglou, E. (1997). The Intestinal Microflora During the First Weeks of Life. *Anaerobe, 3*(2-3), 173-177. doi:10.1006/anae.1997.0102

Boutsen, L., & Marendaz, C. (2001). Detection of shape orientation depends on salient axes of symmetry and elongation: Evidence from visual search. *Perception & Psychophysics, 63*(3), 404-422. doi:10.3758/bf03194408

Bronson, G. (1974). The Postnatal Growth of Visual Capacity. *Child Development,45*(4), 873. doi:10.2307/1128073

Bronson, G. W. (1982). *The scanning patterns of human infants: Implications for visual learning*. Norwood, NJ: Ablex.

Canfield, R. L., Smith, E. G., Brezsnyak, M. P., & Snow, K. L. (1997). Information processing through the first year of life: A longitudinal study using the visual expectation paradigm. *Monographs of the Society for Research in Child Development,* 62, 1-145.

Cardwell, C. R., Stene, L. C., Joner, G., Cinek, O., Svensson, J., Goldacre, M. J., Patterson, C. C. (2008). Caesarean section is associated with an increased risk of childhood-onset type 1 diabetes mellitus: A meta-analysis of observational studies. *Diabetologia, 51*(5), 726-735.

Carrasco, M., Mclean, T. L., Katz, S. M., & Frieder, K. S. (1998). Feature asymmetries in visual search: Effects of display duration, target eccentricity, orientation and spatial frequency. *Vision Research,38*(3), 347-374.

Cave, K. R., (1999). The Feature Gate model of visual selection. *Psychological Research, 4*, 415-429.

Colombo, J., Mitchell, D. W., Coldren, J. T., & Atwater, J. D. (1990). Discrimination learning during the first year: Stimulus and positional cues. *Journal of Experimental Psychology: Learning, Memory, and Cognition,16*(1), 98-109.

Colombo, J., Ryther, J. S., Frick, J. E., & Gifford, J. J. (1995). Visual pop-out in infants: Evidence for preattentive search in 3- and 4-month-olds. *Psychonomic Bulletin & Review, 2*(2), 266-268.

Conway, A. R., & Engle, R. W. (1994). Working memory and retrieval: A resource-dependent inhibition model. *Journal of Experimental Psychology: General,123*(4), 354-373. doi:10.1037//0096-3445.123.4.354

Cryan, J. F., & Dinan, T. G. (2012). Mind-altering microorganisms: The impact of the gut microbiota on brain and behaviour. *Nature Reviews Neuroscience, 13*(10), 701-712.

Dehaene-Lambertz, G., & Spelke, E. S. (2015). The Infancy of the Human Brain. *Neuron Perspective, 88*(1), 93-109. doi:https://doi.org/10.1016/j.neuron.2015.09.026

Desimone, R., & Duncan, J. (1995). Neural Mechanisms of Selective Visual Attention. *Annual Review of Neuroscience, 18*(1), 193-222. doi:10.1146/annurev.neuro.18.1.193

Di Lollo, V., Kawahara, J., Zuvic, S., & Visser, T. (2001). The preattentive emperor has no clothes: A dynamic redressing. *Journal of Experimental Psychology: General, 130,* 479-492.

Diamond, A., & Amso, D. (2008). Contributions of Neuroscience to Our Understanding of Cognitive Development. *Current Directions in Psychological Science, 17*(2), 136-141. doi:10.1111/j.1467-8721.2008.00563.x

Driver, J. (2001). A selective review of selective attention research from the past century. *British Journal of Psychology, 92*(1), 53-78.

Duc, A. H., Bays, P., & Husain, M. (2008). Eye movements as a probe of attention. *Progress in Brain Research Using Eye Movements as an Experimental Probe of Brain Function - A Symposium in Honor of Jean Büttner-Ennever,* 403-411. doi:10.1016/s0079-6123(08)00659-6

Flemming, K., Woolcott, C. G., Allen, A. C., Veugelers, P. J., & Kuhle, S. (2013). The association between caesarean section and childhood obesity revisited: A cohort study. *Archives of Disease in Childhood,98*(7), 526-532.

Galland, L. (2014). The gut microbiome and the brain. *Journal of Medicinal Food*, 17, 1261-1272.

Greenough, W. T., & Black, J. E. (2013). Induction of brain structure by experience: Substrates for cognitive development. In M. R. Gunnar & C. A. Nelson (Eds.), *Developmental behavioral neuroscience: The Minnesota Symposia on Child Psychology* (Vol. 24, pp. 155-200). New York: Psychology Press.

Grölund, M., Lehtonen, O., Eerola, E., & Kero, P. (1999). Fecal Microflora in Healthy Infants Born by Different Methods of Delivery: Permanent Changes in Intestinal Flora After Cesarean Delivery. *Journal of Pediatric Gastroenterology & Nutrition, 28*(1), 19-25.

Haith, M. M., Hazan, C., & Goodman, G. S. (1988). Expectation and Anticipation of Dynamic Visual Events by 3.5-Month-Old Babies. *Child Development, 59*(2), 467-479.

Johnson, M. H. (1990). Cortical Maturation and the Development of Visual Attention in Early Infancy. *Journal of Cognitive Neuroscience, 2*(2), 81-95. doi:10.1162/jocn.1990.2.2.81

Jones, S. R., Kerr, C. E., Wan, Q., Pritchett, D. L., Hamalainen, M., & Moore, C. I. (2010). Cued Spatial Attention Drives Functionally Relevant Modulation of the Mu Rhythm in Primary Somatosensory Cortex. *Journal of Neuroscience, 30*(41), 13760-13765.

Julesz, B. (1984). A brief outline of the texton theory of human vision. *Trends in Neurosciences,7*(2), 41-45.

Levin, D. T., & Angelone, B. L. (2001). Visual search for a socially defined feature: What causes the search asymmetry favoring cross-race faces? *Perception & Psychophysics, 63*(3), 423-435. doi:10.3758/bf03194409

Kröse, B. J., & Julesz, B. (1989). The control and speed of shifts of attention. *Vision Research, 29*(11), 1607-1619.

May, C. P., Hasher, L., & Kane, M. J. (1999). The role of interference in memory span. *Memory & Cognition, 27*(5), 759-767. doi:10.3758/bf03198529

Maurer, D., Ellemberg, D., & Lewis, T. L. (2006). Repeated measurements of contrast sensitivity reveal limits to visual plasticity after early binocular deprivation in humans. *Neuropsychologia,44*(11), 2104-2112.

Mohades, S. G., Struys, E., Van Schuerbeek, P., Mondt, K., Van De Craen, P., & Luypaert, R. (2012). DTI reveals structural differences in white matter tracts between bilingual and monolingual children. *Brain Research*, *1435,* 72-80. doi: 10.1016/j.brainres.2011.12.005

Moran, J., & Desimone, R. (1985). Selective attention gates visual processing in the extrastriate cortex. *Science, 229*(4715), 782-784. doi:10.1126/science.4023713

Nagy, A. L., & Cone, S. M. (1996). Asymmetries in Simple Feature Searches for Color. *Vision Research,36*(18), 2837-2847.

Neisser, U. (1966). *Cognitive psychology*. New York: Appleton-Century-Crofts.

Palmer, E. M., Fencsik, D. E., Flusberg, S. J., Horowitz, T. S., & Wolfe, J. M. (2011). Signal detection evidence for limited capacity in visual search. *Attention, Perception, & Psychophysics,73*(8), 2413-2424.

Petersen, S. E., & Posner, M. I. (2012). The Attention System of the Human Brain: 20 Years After. *Annual Review of Neuroscience, 35*(1), 73-89. doi:10.1146/annurev-neuro-062111-150525

Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology*, 32, 3-25.

Posner, M. I. (2016). Orienting of Attention: Then and Now. *Quarterly Journal of Experimental Psychology, 69*(10), 1864-1875. doi:10.1080/17470218.2014.937446

Posner, M. I., & Petersen, S. E., (1990). The attention system of the human brain. *Annual Review of Neuroscience. 13*, 25-42.

Quigley, M. A., Hockley, C., Carson, C., Kelly, Y., Renfrew, M. J., & Sacker, A. (2012). Breastfeeding is associated with improved child cognitive development: A population-based cohort study. *Journal of Pediatrics, 160*, 25-32.

Renz-Polster, H., David, M. R., Buist, A. S., Vollmer, W. M., O'Connor, E. A., Frazier, E. A., & Wall, M. A. (2005). Caesarean section delivery and the risk of allergic disorders in childhood. *Clinical and Experimental Allergy, 35*, 1466-1472.

Rose, S. A., Feldman, J. F., & Jankowski, J. J. (2004). Dimensions of cognition in infancy. *Intelligence,32*(3), 245-262.

Royden, C. S., Wolfe, J. M., & Klempen, N. (2001). Visual search asymmetries in motion and optic flow fields. *Perception & Psychophysics, 63*(3), 436-444.

Shen, J., & Reingold, E. M. (2001). Visual search asymmetry: The influence of stimulus familiarity and low-level features. *Perception & Psychophysics, 63*(3), 464-475. doi:10.3758/bf03194413

Theeuwes, J. (1994). Endogenous and Exogenous Control of Visual Selection. *Perception, 23*(4), 429-440.

Theeuwes, J. (2010). Top-down and bottom-up control of visual selection: Reply to commentaries. *Acta Psychologica, 135*(2), 133-139.

Theeuwes, J., & Belopolsky, A. (2010). Top-down and bottom-up control of visual search: Controversies and debate. In V. Coltheart (Ed.), *Tutorials in visual cognition* (pp. 67-92). New York: Psychology Press.

Theeuwes, J., Kramer, A. F., Atchley, P. (1999) Attentional effects on preattentive vision: Spatial cues affect the detection of simple features. *Journal of Experimental Psychology: Human Perception and Performance, 25*, 341-347.

Toda, T., Homma, D., Tokuoka, H., Hayakawa, I., Sugimoto, Y., Ichinose, H., & Kawasaki, H. (2013). Birth Regulates the Initiation of Sensory Map Formation through Serotonin Signaling. *Developmental Cell*,*27*(1), 32-46.

Treisman, A. (1986). Visual Information Processing in the Perception of Features and Objects. *255*(5), 114-125.

Treisman, A. M., & Gelade, G. (1980). A Feature-Integration Theory of Attention. *Cognitive Psychology,* 12, 97-106.

Treisman, A., & Gormican, S. (1988). Feature Analysis in Early Vision. Evidence from search asymmetries. *Psychological Review,* 95, 15-48.

Treisman, A., & Souther, J. (1985). Search asymmetry: A diagnostic for preattentive processing of separable features. *Journal of Experimental Psychology: General, 114*(3), 285-310.

Wolfe, J. M. (1994). Guided Search 2.0: A revised model of visual search. *Psychonomic Bulletin and Review, 1,* 202-238.

Wolfe, J. M. (1998). What can 1 million trials tell us about visual search? *Psychological Science, 9,* 33-39.

Wolfe, J. M. (2001). Asymmetries in visual search: An introduction. *Perception & Psychophysics, 63,* 381-389.

Wolfe, J. M. (2007). Guided Search 4.0: Current progress with a model of visual search. In W. Gray (Ed.), *Integrated models of cognitive systems* (pp. 99-119). Oxford: New York.

Wolfe, J. M. (2010). Guided Search 4.0: A guided search model that does not require memory for rejected distractors. *Journal of Vision,1*(3), 349-349.

Wolfe, J. M., Cave, K. R., & Franzel, S. L. (1989). Guided search: An alternative to the feature integration model for visual search. *Journal of Experimental Psychology: Human Perception and Performance,15*(3), 419-433.

Wolfe, J. M., & Horowitz, T. S. (2004). Opinion: What attributes guide the deployment of visual attention and how do they do it? *Nature Reviews Neuroscience,5*(6), 495-501.

Yantis, S., & Egeth, H. E. (1999). On the distinction between visual salience and stimulus-driven attention capture. *Journal of Experimental Psychology: Human Perception and Performance, 25*(3), 661-676. doi:10.1037//0096-1523.25.3.661

Appendix

Table 1

Average error rate for infant participants across all birth experience groups, conditions, and set sizes.

BIRTH EXPERIENCE	SET SIZE	CONDITION	AVERAGE ERROR RATE
Vaginal	3	R	0.38
	5		0.20
	8		0.50
Vaginal	3	R	0.29
	5		0.18
	8		0.20
Vaginal	3	R	0.20
	5		0.50
	8		0.17
Vaginal	3	R	0.36
	5		0.50
	8		0.56
Vaginal	3	R	0.50
	5		0.29
	8		0.00
Vaginal	3	R	0.33
	5		0.40
	8		0.20
Vaginal	3	R	0.25
	5		0.25
	8		0.50
Vaginal	3	R	0.29
	5		0.25
	8		0.43
Vaginal	3	R	0.75
	5		0.33
	8		0.44
Vaginal	3	R	0.22

	5		0.14
	8		0.33
Vaginal	3	P	0.29
	5		0.38
	8		0.20
Vaginal	3	P	0.22
	5		0.27
	8		0.20
Vaginal	3	P	0.20
	5		0.40
	8		0.60
Vaginal	3	P	0.44
	5		0.60
	8		0.20
Vaginal	3	P	0.29
	5		0.38
	8		0.10
Vaginal	3	P	0.40
	5		0.50
	8		0.17
Vaginal	3	P	0.33
	5		0.33
	8		0.33
Vaginal	3	P	0.30
	5		0.25
	8		0.25
Vaginal	3	P	0.00
	5		0.80
	8		0.33
Vaginal	3	P	0.57
	5		0.33
	8		0.22
C. Planned	3	R	0.38
	5		0.29
	8		0.33
C. Planned	3	R	0.40
	5		0.18
	8		0.21
C. Planned	3	R	0.33

	5		0.27
	8		0.21
C. Planned	3	R	0.29
	5		0.40
	8		0.30
C. Planned	3	R	0.14
	5		0.20
	8		0.25
C. Planned	3	R	0.25
	5		0.29
	8		0.22
C. Planned	3	R	0.40
	5		0.50
	8		0.50
C. Planned	3	R	0.38
	5		0.44
	8		0.43
C. Planned	3	R	0.40
	5		0.57
	8		0.25
C. Planned	3	P	0.45
	5		0.33
	8		0.22
C. Planned	3	P	0.44
	5		0.25
	8		0.17
C. Planned	3	P	0.25
	5		0.27
	8		0.15
C. Planned	3	P	0.40
	5		0.20
	8		0.29
C. Planned	3	P	0.29
	5		0.22
	8		0.14
C. Planned	3	P	0.33
	5		0.17
	8		0.13
C. Planned	3	P	0.33

	5		0.50
	8		0.14
C. Planned	3	P	0.45
	5		0.27
	8		0.50
C. Planned	3	P	0.44
	5		0.50
	8		0.14
C. Emergency	3	R	0.55
	5		0.29
	8		0.33
C. Emergency	3	R	0.27
	5		0.44
	8		0.40
C. Emergency	3	R	0.33
	5		0.40
	8		0.33
C. Emergency	3	R	0.38
	5		0.20
	8		0.50
C. Emergency	3	R	0.57
	5		0.40
	8		0.40
C. Emergency	3	R	0.38
	5		0.25
	8		0.27
C. Emergency	3	R	0.50
	5		0.33
	8		0.20
C. Emergency	3	R	0.57
	5		0.50
	8		0.57
C. Emergency	3	P	0.33
	5		0.22
	8		0.25
C. Emergency	3	P	0.18
	5		0.33
	8		0.27
C. Emergency	3	P	0.31

	5		0.38
	8		0.27
C. Emergency	3	P	0.11
	5		0.43
	8		0.22
C. Emergency	3	P	0.30
	5		0.38
	8		0.14
C. Emergency	3	P	0.38
	5		0.25
	8		0.27
C. Emergency	3	P	0.50
	5		0.33
	8		0.25
C. Emergency	3	P	0.50
	5		0.67
	8		0.60

Table 2

Average error rate for adult participants across all birth experience groups, conditions, and set sizes.

BIRTH EXPERIENCE	SET SIZE	CONDITION	AVERAGE ERROR RATE
Vaginal	3	R	0.13
	5		3.00
	8		15.00
Vaginal	3	R	0.19
	5		0.13
	8		0.35
Vaginal	3	R	0.33
	5		0.50
	8		0.54
Vaginal	3	R	0.47
	5		0.40
	8		0.58
Vaginal	3	R	0.36
	5		0.22
	8		0.50
Vaginal	3	R	0.00
	5		0.00
	8		0.00
Vaginal	3	R	0.06
	5		0.38
	8		0.44
Vaginal	3	R	0.07
	5		0.36
	8		0.67
Vaginal	3	R	0.15
	5		0.36
	8		0.40
Vaginal	3	R	0.20
	5		0.44
	8		0.50

Vaginal	3	P	0.47
	5		0.38
	8		0.47
Vaginal	3	P	0.13
	5		0.40
	8		0.44
Vaginal	3	P	0.60
	5		0.45
	8		0.71
Vaginal	3	P	0.27
	5		0.42
	8		0.54
Vaginal	3	P	0.45
	5		0.42
	8		0.36
Vaginal	3	P	0.13
	5		0.06
	8		0.25
Vaginal	3	P	0.38
	5		0.38
	8		0.50
Vaginal	3	P	0.13
	5		0.50
	8		0.80
Vaginal	3	P	0.25
	5		0.42
	8		0.50
Vaginal	3	P	0.25
	5		0.33
	8		0.60
C. Planned	3	R	0.00
	5		0.00
	8		0.40
C. Planned	3	R	0.64
	5		0.80
	8		0.36
C. Planned	3	R	0.29
	5		0.45
	8		0.70

C. Planned	3	R	0.45
	5		0.17
	8		0.25
C. Planned	3	R	0.43
	5		0.75
	8		0.33
C. Planned	3	R	0.23
	5		0.33
	8		0.25
C. Planned	3	R	0.44
	5		0.50
	8		0.63
C. Planned	3	R	0.33
	5		0.27
	8		0.50
C. Planned	3	R	0.38
	5		0.25
	8		0.63
C. Planned	3	R	0.55
	5		0.25
	8		0.75
C. Planned	3	P	0.00
	5		0.00
	8		0.33
C. Planned	3	P	0.64
	5		0.63
	8		0.79
C. Planned	3	P	0.71
	5		0.50
	8		0.64
C. Planned	3	P	0.42
	5		0.40
	8		0.50
C. Planned	3	P	0.35
	5		0.21
	8		0.47
C. Planned	3	P	0.18
	5		0.15
	8		0.40

C. Planned	3	P	0.06
	5		0.60
	8		0.41
C. Planned	3	P	0.25
	5		0.17
	8		0.20
C. Planned	3	P	0.38
	5		0.10
	8		0.31
C. Planned	3	P	0.36
	5		0.27
	8		0.62
C. Emergency	3	R	0.20
	5		0.44
	8		0.71
C. Emergency	3	R	0.25
	5		0.36
	8		0.50
C. Emergency	3	R	0.10
	5		0.27
	8		0.31
C. Emergency	3	R	0.29
	5		0.19
	8		0.21
C. Emergency	3	R	0.22
	5		0.15
	8		0.59
C. Emergency	3	R	0.19
	5		0.06
	8		0.53
C. Emergency	3	R	0.17
	5		0.08
	8		0.53
C. Emergency	3	R	0.25
	5		0.18
	8		0.20
C. Emergency	3	R	0.33
	5		0.45
	8		0.36

C. Emergency	3	R	0.00
	5		0.00
	8		0.40
C. Emergency	3	P	0.20
	5		0.18
	8		0.50
C. Emergency	3	P	0.19
	5		0.27
	8		0.50
C. Emergency	3	P	0.18
	5		0.00
	8		0.38
C. Emergency	3	P	0.15
	5		0.33
	8		0.54
C. Emergency	3	P	0.44
	5		0.50
	8		0.56
C. Emergency	3	P	0.21
	5		0.40
	8		0.50
C. Emergency	3	P	0.21
	5		0.17
	8		0.58
C. Emergency	3	P	0.17
	5		0.06
	8		0.50
C. Emergency	3	P	0.29
	5		0.21
	8		0.54
C. Emergency	3	P	0.40
	5		0.11
	8		0.50